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space/aeronautics

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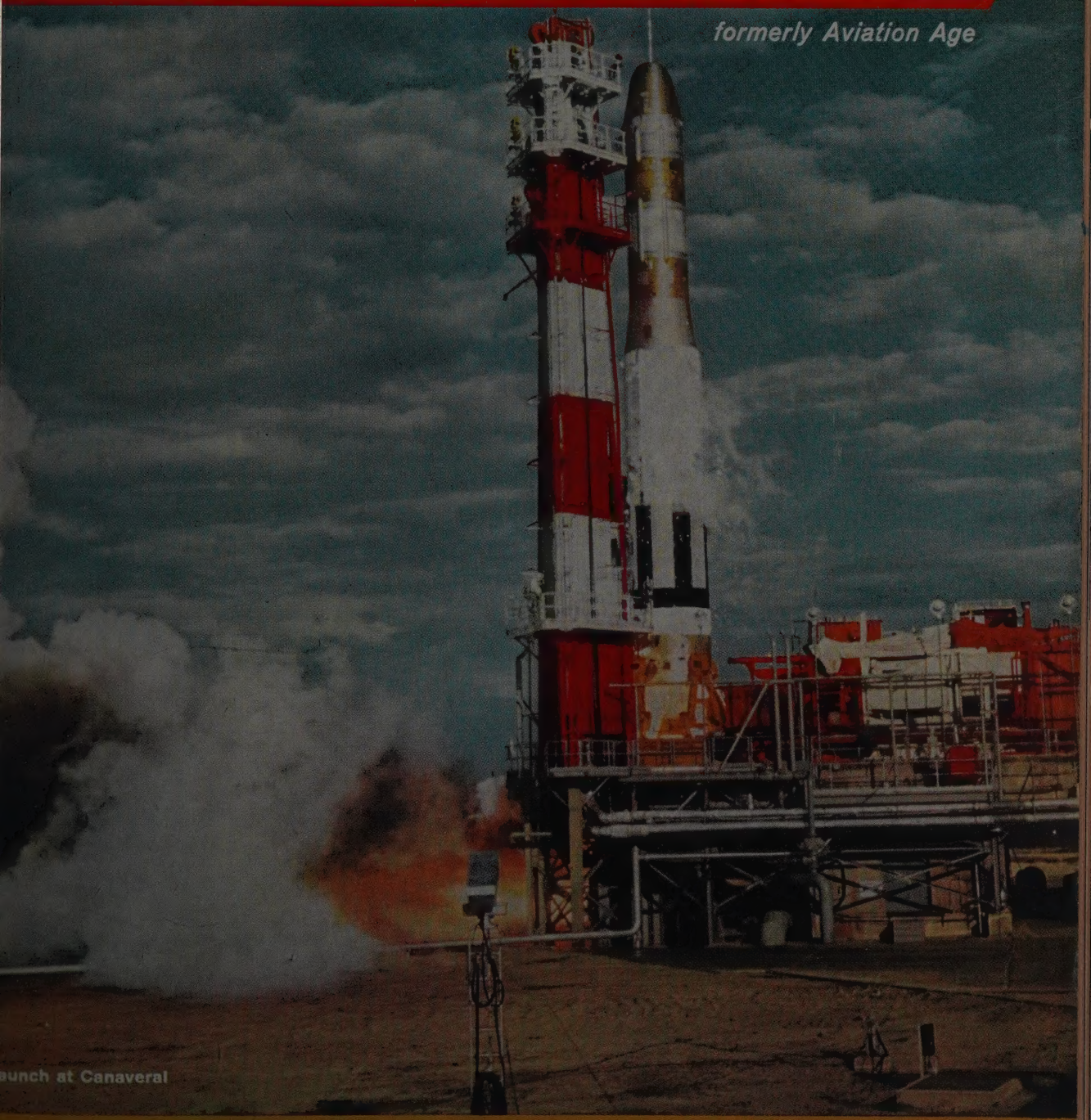

aunch at Canaveral

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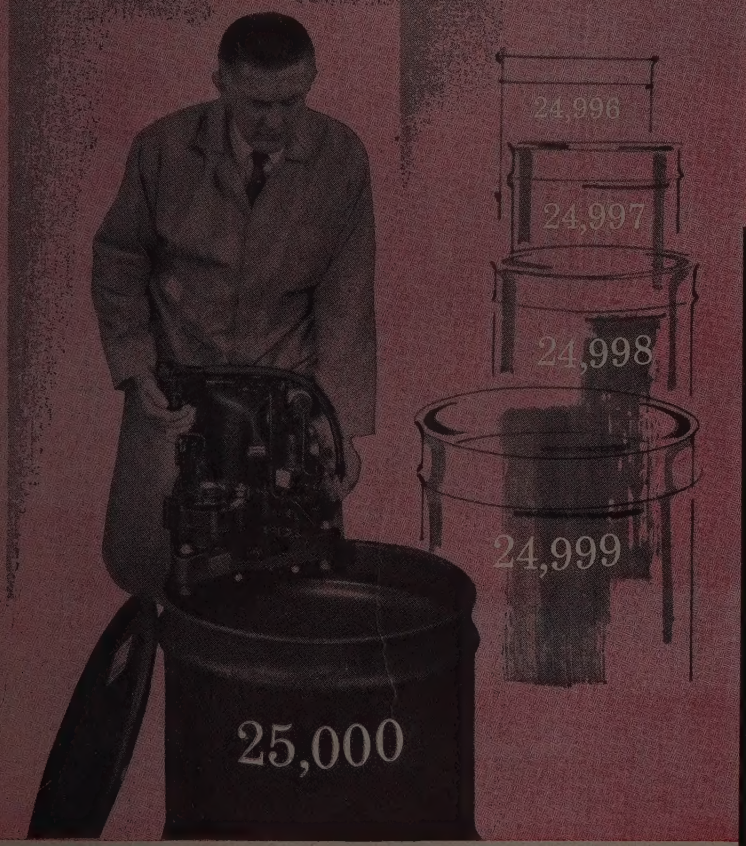

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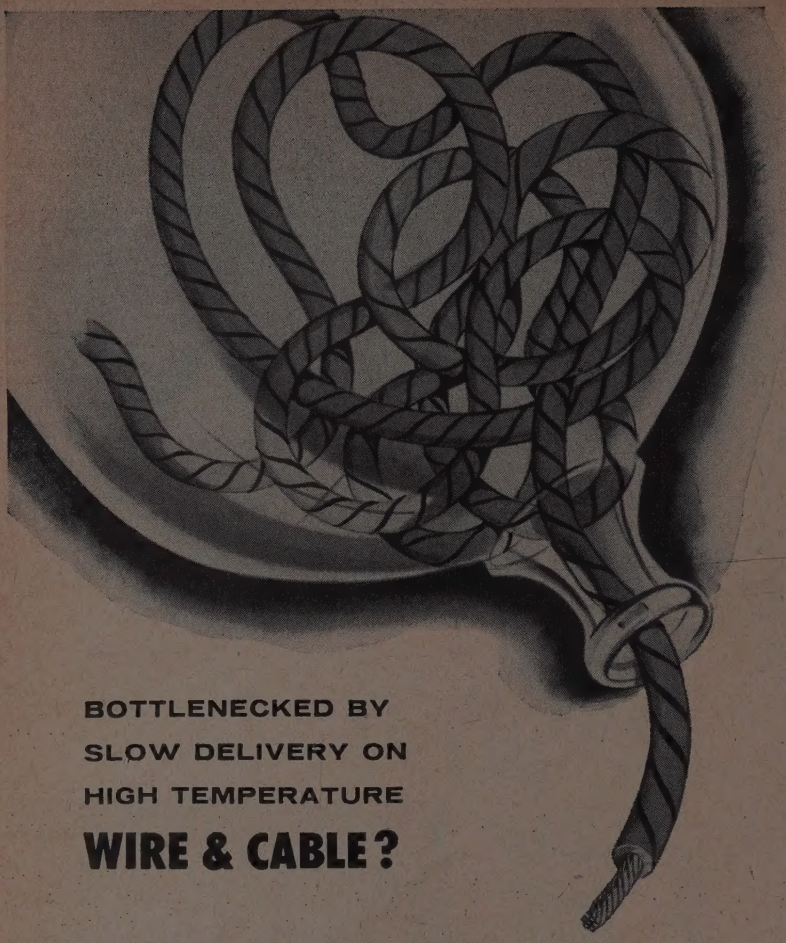

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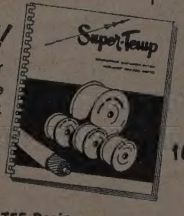

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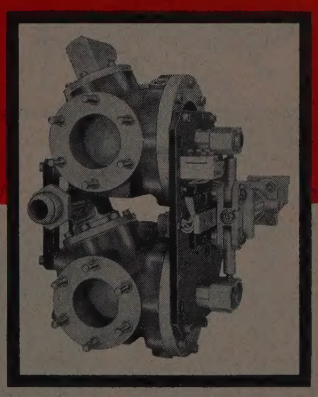

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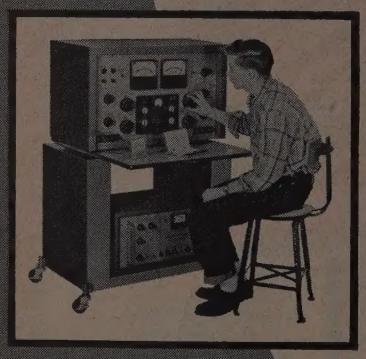

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cover story

Important stage in development of USAF's Titan ICBM was reached with recent first launching from Cape Canaveral, Fla. The two-stage missile is designed for a range of 5500 miles, but this reportedly may be extended to 9000 miles.

Martin-Denver is principal contractor on the Titan. The three liquid propellant engines, which can develop a reported 360,000 lb of thrust, are from Aerojet-General, as is the APU system. The all-inertial guidance system is being developed by Arma. The nose cone is an Avco design.

The picture above of a first-stage dummy gives an idea of the Titan's dimensions. It was taken in the course of GSE tests made by American Machine & Foundry.

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Lightweight, compact NASARR is the only system in production that is equally effective for air search, automatic tracking, air-to-ground slant ranging, and terrain avoidance—from sea level to stratosphere. Accurate ground mapping rounds out NASARR's uncanny versatility.

Autonetics builds NASARR for the AN/ASG-19 armament control system—standard equipment for advanced versions of the F-105. Like all Autonetics guidance and control systems, NASARR does its delicate work *reliably* under extremes of speed, altitude, and temperature.

NASARR is one example of the type of system that is resulting from Autonetics' decade of development in monopulse radar.

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April 1959

volume 31, number 4

space/aeronautics

RESEARCH · DESIGN · DEVELOPMENT

aircraft / missiles / spacecraft

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Titan nose cone from Avco — The recent flight of the Air Force Titan ICBM was achieved by the free world's most advanced rocket technologists. Avco scientists and engineers, pioneers in missile reentry work, are members of the Titan team. They are contributing a reentry vehicle designed to withstand the scorching friction during the reentry phase of the ICBM's planned intercontinental range flight. And now, Avco has been chosen as the associate contractor for the reentry vehicle of the next Air Force ICBM . . . the mighty, solid-fueled Minuteman.

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in this issue

Here's a quick rundown of the technical information offered in the articles in this issue. You can also use these article abstracts to build up your own permanent record for reference in the future—just clip them, paste them up on standard three-by-five cards, and file them.

Space/Aero Engineering
Systems Engineering, Aerodynamics, Structures, Propulsion

Astia code: 1-2, -3; 27
Your code:

Mach 3-5 airliners look economically feasible

Analysis of economics of flight at super- and hypersonic speeds with commercial transport aircraft. Probable trends in airframe weight, powerplant efficiency, aerodynamics, etc., are discussed and used for estimates of relative fleet costs at up to Mach 12.

by J. L. Jones & D. H. Dennis, NASA
space/aeronautics 31/4 (Apr. '59) **p. 41**

Space/Aero Engineering
Structures, Materials, Production Engineering

Astia code: 1-2, -3; 17-4, -5; 26-1
Your code:

DC-8 structure: New fail-safe approaches (Design Progress)

Design details of new Douglas jet transport, including wing layout, horizontal stabilizer, windows, fuselage splices, and frames. Fail-safe features, such as use of very large wing skins and titanium "rip stoppers," are discussed.

by Irwin Stambler, Associate Editor
space/aeronautics 31/4 (Apr. '59) **p. 55**

Space/Aero Engineering
Accessory Systems

Astia code: 2-1; 7-5; 14-6
Your code:

Solar cell R&D shooting for 16-22 per cent efficiencies

Design considerations for solar cell systems, with emphasis on electromechanical and thermal factors. R&D programs to improve efficiencies and find new ways of producing cells are reviewed. Graphs of silicon solar cell characteristics and configurations of oriented systems.

by Joseph I. Davies, Hoffman Labs.
space/aeronautics 31/4 (Apr. '59) **p. 44**

Space/Aero Engineering
Propulsion, Systems Engineering

Astia code: 12-4; 27-3
Your code:

Liquid injection for solid rocket thrust control

Evaluation of three typical liquids—water, ethylene oxide, and hydrogen peroxide and hydrazine 6; propellant mixture—for solid rocket thrust control. Effects of injection on thrust variables are shown, and propulsion system and overall missile weight penalties and thrust control ranges are discussed.

by Michael Grenus, Chrysler
space/aeronautics 31/4 (Apr. '59) **p. 59**

Space/Aero Engineering
Propulsion

Astia code: 21-3, -4, -5, -7, -8, -9
Your code:

First airborne atomic engines will be nuclear-chemical hybrids

Analysis of possible configurations for engines using nuclear reactor as energy source, covering ramjets and turbojets and supplementary heating of air flow past the reactor. Diagrams show likely arrangement of major items. Temperatures, compression ratios, engine sizes, and thrust levels are given for hypothetical designs.

by G. N. Nesterenko, A. I. Sobolev & Yu. N. Sushkov
space/aeronautics 31/4 (Apr. '59) **p. 47**

Space/Aero Engineering
Ground Support, Propulsion

Astia code: 12-3, -4; 27-3
Your code:

Designing a jet deflector for the Hawk launcher

Development history of diffuser-type deflector designed to prevent soil erosion from jet blast around the Hawk launch position. Scale model test setup is described and diagramed and results are given for solid deflectors, deflectors with circular holes, and slotted deflectors. Problems of deflector positioning are discussed in detail.

by J. A. Quinville, Northrop
space/aeronautics 31/4 (Apr. '59) **p. 63**

Space/Aero Engineering
Accessory Systems

Astia code: 7-5
Your code:

Variable-speed, synchronous-flux generator delivers 20-120 kva

Analysis of design and performance of Jack & Heintz variable-speed, constant-frequency system for airborne use. Block diagram, cutaway of variable-speed generator, test oscillograms of system performance for resistive-inductive loads, tabular comparison with other systems by weight, size, and complexity are shown.

by Victor DeBiasi, Associate Editor
space/aeronautics 31/4 (Apr. '59) **p. 50**

Space/Aero Engineering
Production Engineering, Structures

Astia code: 1-3; 26-1
Your code:

Butt welding proves out for thin gages

Tooling setup for and results of fusion welding and roll planishing process applied on production basis to sheet as thin as 0.003 in. and said to give stronger and smoother seams and good post-weld formability for curved parts. Test data are given on tensile strength in as-welded and roll-planished conditions.

by Gilbert C. Close, Technical Contributor
space/aeronautics 31/4 (Apr. '59) **p. 81**

To make filing easier, each abstract is coded according to the Astia Distribution Guide. Copies of this guide are available from Armed Forces Technical Information Agency, Arlington Hall Sta., Arlington 12, Va. There is also room on the abstracts for you to insert your own key if you use a special coding system.

Space/Aero Engineering
Accessory Components, Structures

Astia code: 1-3; 12-1
Your code:

Integrated seals simplify Tartar design

Use of gland-type, mechanical, integrated seals on Tartar missile. Its almost leakproof standards are discussed and a description of the seal design is given.

by Wendel Haas, Convair
space/aeronautics 31/4 (Apr. '59) **p. 89**

Space/Aero Engineering
Materials, Structures

Astia code: 1-3; 12-1; 17-4
Your code:

Molybdenum coating stands up at 2000 deg F

Description of composite electrodeposited coating for molybdenum developed by National Bureau of Standards. Results of tests are discussed in which coated Mo specimens withstood temperatures of 980 and 1100 deg C for over 1000 and 300 hours, respectively.

by Irwin Stambler, Associate Editor
space/aeronautics 31/4 (Apr. '59) **p. 97**

Space/Aero Engineering
Testing, Accessory Components

Astia code: 30-4
Your code:

GOX lab simulates combined environments

New Whittaker Controls gaseous oxygen laboratory. Its types of equipment and their capabilities for testing such missile components as cryogenic dump valves are discussed.

by Irwin Stambler, Associate Editor
space/aeronautics 31/4 (Apr. '59) **p. 103**

Space/Aero Engineering
Ground Support, Testing, Propulsion

Astia code: 12-3, -4
Your code:

Load cells measure Atlas weight and thrust to 50 lb

Instrumentation setup used to weigh Atlas missile empty, during fueling, and for "hold" periods on the launch pad. Same equipment is used for measuring thrust force components during static firing tests. Schematic of load cell arrangement and block diagram of instrumentation system.

by R. J. Carleton, Jr., Gilmore Industries
space/aeronautics 31/4 (Apr. '59) **p. 115**

Space/Aero Electronics

Astia code: 8-6
Your code:

Millimeter waves—future depends on component development

Review of millimeter wave applications and development trends. Unclassified high and low power signal sources and new approaches to MM generation are discussed. Recently declassified high definition MM radar design characteristics are presented.

by James Holahan, Electronics Editor
space/aeronautics 31/4 (Apr. '59) **p. 134**

Space/Aero Electronics

Astia code: 8-2
Your code:

Magnetic clutches add muscle to electronic servos

Details of dry-powder magnetic clutch servo. Fundamentals of magnetic clutch design, closed-loop operation, and dynamic response are discussed. Examples of various magnetic clutch servos are shown. Torque output vs input current, response of biased pairs, and torque-speed characteristics are graphed.

by Dunstan Graham, Lear
space/aeronautics 31/4 (Apr. '59) **p. 138**

Space/Aero Electronics

Astia code: 8-1
Your code:

When you can use microwave lenses

Detailed review of advantages and applications of the various types of microwave radar lens antennas (constrained and unconstrained media with constant or variable refractive index). Design principle of "ray tracing" is explained. Problems of zoning and surface matching are analyzed.

by R. W. Martin & W. M. Yarnell, Sperry Gyroscope
space/aeronautics 31/4 (Apr. '59) **p. 142**

Space/Aero Electronics

Astia code: 6-3; 8-2, -6
Your code:

Microwave IR detector has higher S/N, broad BW (Design Digest)

Analysis of novel infrared detector combining microwave concepts with IR sensing elements to get high sensitivity. Lab setup, microwave hardware design, IR optics, and measurement apparatus are shown. Performance factors are tabulated and system operation is outlined.

by Bernard Kovit, Associate Electronics Editor
space/aeronautics 31/4 (Apr. '59) **p. 147**

continued on page 13

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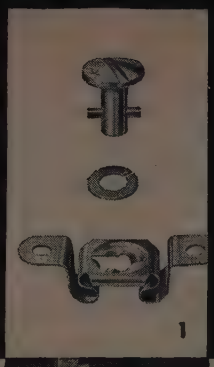

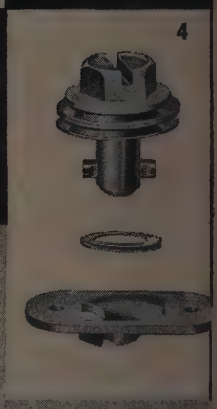

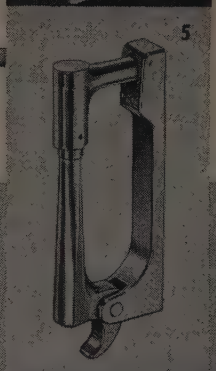

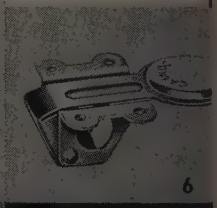

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4. 91F Heavy Duty Quarter-Turn
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9. 4002 Series Quarter-Turn
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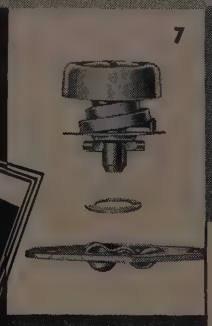

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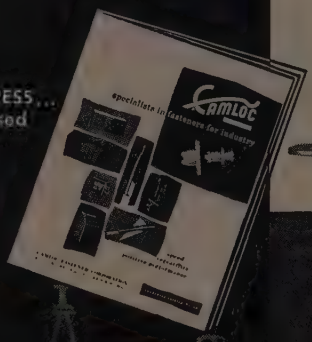

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in this issue continued from page 11

Space/Aero Electronics — Astia code: 6-3 Your code:

Infrared detection by recon satellite

Concluding article in two-part series on problems of designing a satellite system for missile detection and IR reconnaissance. Factors affecting an IR mapping system are analyzed. Atmospheric transmission spectrum of earth's radiation, bandwidths, and altitude and temperature effects on resolution are graphed.

by Du Mont Labs
space/aeronautics 31/4 (Apr. '59) p. 151

Space/Aero Electronics — Astia code: 8-2 Your code:

Lax specs cause confusion in rate gyro field

In view of the danger that ambiguous terms and test procedures will keep systems engineers from getting the best available rate gyro designs, pertinent design parameters are defined. Interrelationships of these parameters are shown, and performance characteristics are defined.

by Norman W. Batterman, R. C. Allen Aircraft Instrument
space/aeronautics 31/4 (Apr. '59) p. 159

Space/Aero Electronics — Astia code: 8-6 Your code:

RF loss through rocket flame easy to figure

Review of problems of radio propagation through rocket exhaust flames. Effect of flame expansion in low ambient pressure of high altitudes is described. Total attenuations through typical flame are obtained by simple analysis.

by R. J. Schmelzer, Lockheed Aircraft
space/aeronautics 31/4 (Apr. '59) p. 171

coming next month

WHAT MAKES a 1200-mph fighter tick? Watch for extensive engineering details in next month's Design Progress on one of the most advanced recent interceptor designs.

WITH EVERY new missile that is tested, the role of telemetry becomes more important—and so does the solution of several basic problems that have been bedeviling telemetry designers ever since their art began to grow overnight like Topsy. A report on our progress toward this solution will be given in an article on "second-generation telemetry.

TIME DILATION very likely is the most intriguing problem of "deep" space flights. That it's the most confusing problem is even more likely. To make things a bit clearer, SPACE/AERONAUTICS will bring you a summary of the best physicists' guesses on this brain-twister.

coming soon

EUROPE'S contribution to space/aero progress will be exhaustively described and analyzed in a SPACE/AERONAUTICS special report in June.

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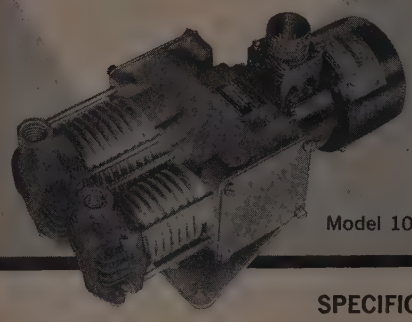

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behind the scenes

by **Randolph Hawthorne**, Editor

Go-ahead hinged on breadboard model's success

OUR EDITORS often run across information which never gets into print. As engineers, they see and hear much that has no direct bearing on the editorial service we try to perform for our readers.

For instance, many of the problems an R&D engineer faces often have nothing to do directly with the technical article about the component or system under development. A case in point showed up during a recent visit to Jack & Heintz in Cleveland. Getting material for his article on the J&H variable-speed, constant-frequency generating system (*page 50*), Associate Editor Vic DeBiasi learned that when the company decided to go ahead with development, it knew a vital part to the solution of its hardware problem was still an experimental unknown. The vital component was a controlled rectifier.

Rectifier had to be simulated

GE was said to have an experimental prototype. But there still was an unpredictable amount of work to be done before the rectifier would be available as a production item in the power rating needed.

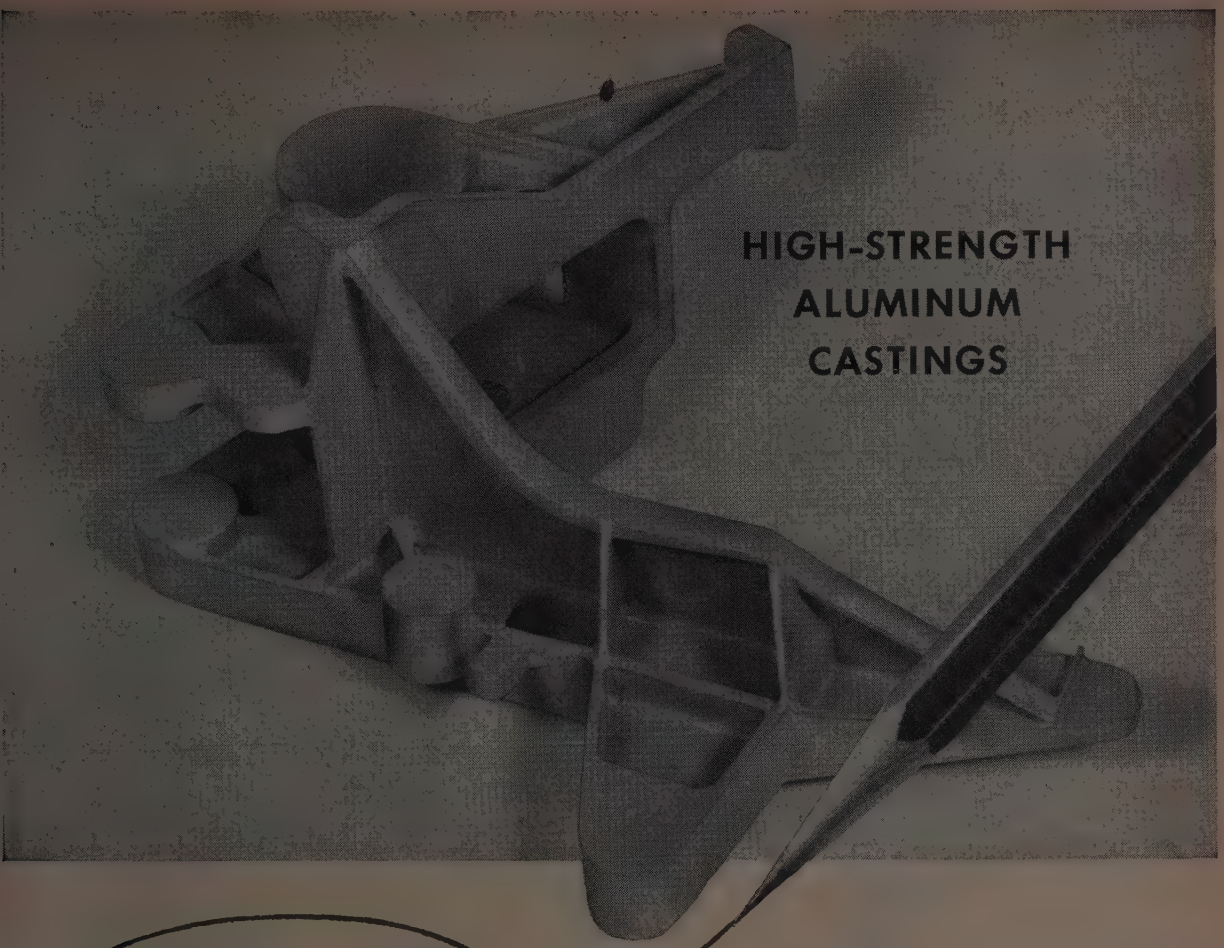
Nevertheless, J&H decided to go ahead. But to do so, its engineers had to simulate the operation of a controlled rectifier in their own experimental breadboard setups.

The controlled rectifier is a small item about the size of a miniature toggle switch. But it took about 14 electrical components—power transistors, resistors, capacitors, and chokes, mounted on a board about 12x18 in.—to faithfully simulate the rectifier.

It was a critical engineering problem, J&H told Vic, to come up with this breadboard substitute. In place of a silicon-controlled rectifier, they used germanium power transistors and associated circuitry to stimulate the rectifier's behavior. While this substitution didn't affect the method of operation of the VSCF system, J&H explained, it did limit the current and voltage capabilities of the frequency changer and, as a result, the power rating of the breadboard setup.

However, the primary purpose of the hardware—to show the feasibility of the VSCF system—was achieved through this breadboard setup. Although an indispensable part of the development program, it is but incidental to the technical article Vic was to write for this issue, which deals with the completed system.

There are many such stories behind stories in the development programs of products.



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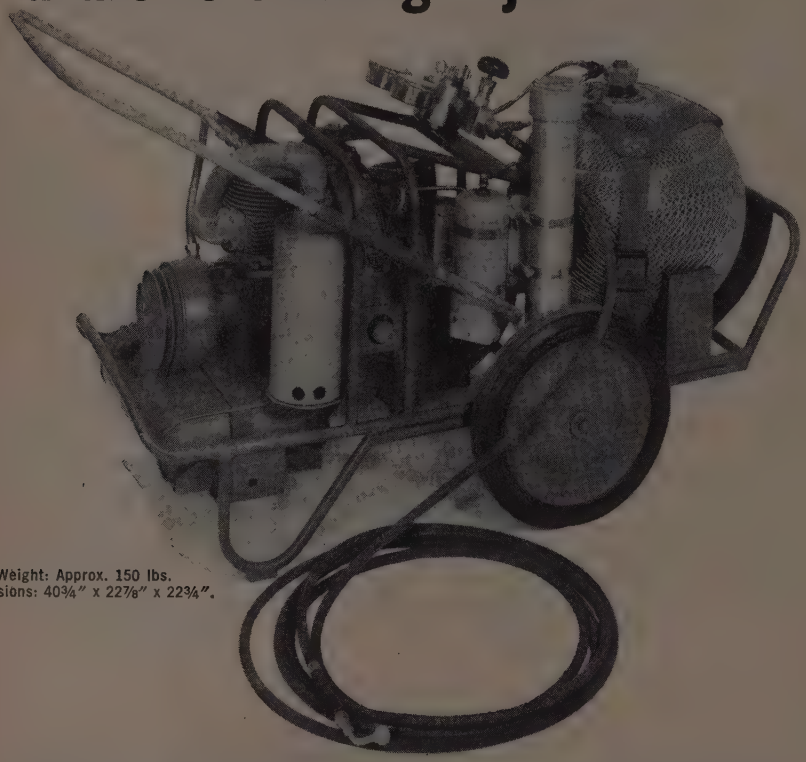

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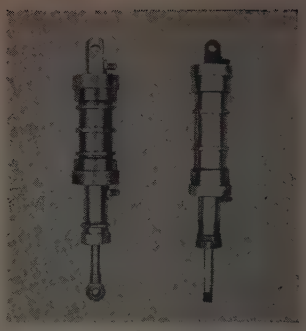

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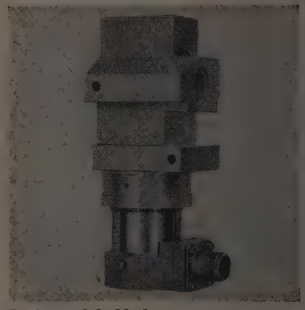

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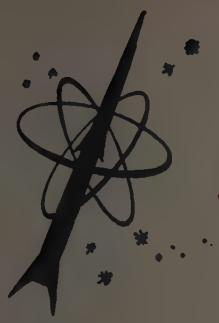


editorial

Salvation and Solvency

A SENATE subcommittee will look into "wasteful rivalry and duplication" in our space programs. We hope the result will be effective remedy.

The committee will find what it sets out to find. There is waste and duplication. But not just in space programs.

The Administration "backed" into space flight because of pressure following the sputniks. The military are in it because of their conceptions of their roles and missions. They also are in it because the Administration never clearly defined our objectives. It has never done so (1) because it never fully believed in the value of space programs and (2) because it is obsessed with "economy".

The President's idea of economy is to cut back military spending. Congress's idea is to cut foreign military and economic aid, and wherever it doesn't affect the flow of federal money into their constituents' pockets. The two ideas of economy are like the refrain on East and West: ". . . and ne'er the twain will meet."

IN THE FIRST PLACE, neither Congress nor the President looks squarely in the face the enormous threat to civilization in general, and to the U.S. specifically. If they did, there would be a complete change of mentality on both sides to meet the threat effectively and economically.

The President claims to be the best judge on Pentagon matters—meaning the military requirements for defense. Plainly, he doesn't believe his service chiefs who "live" with the problem. Cuts in military preparedness are made over their protests and in the face of mounting Soviet belligerence.

Congress, loudly appealing for more military strength, nevertheless continues to act on a "politics as usual" basis.

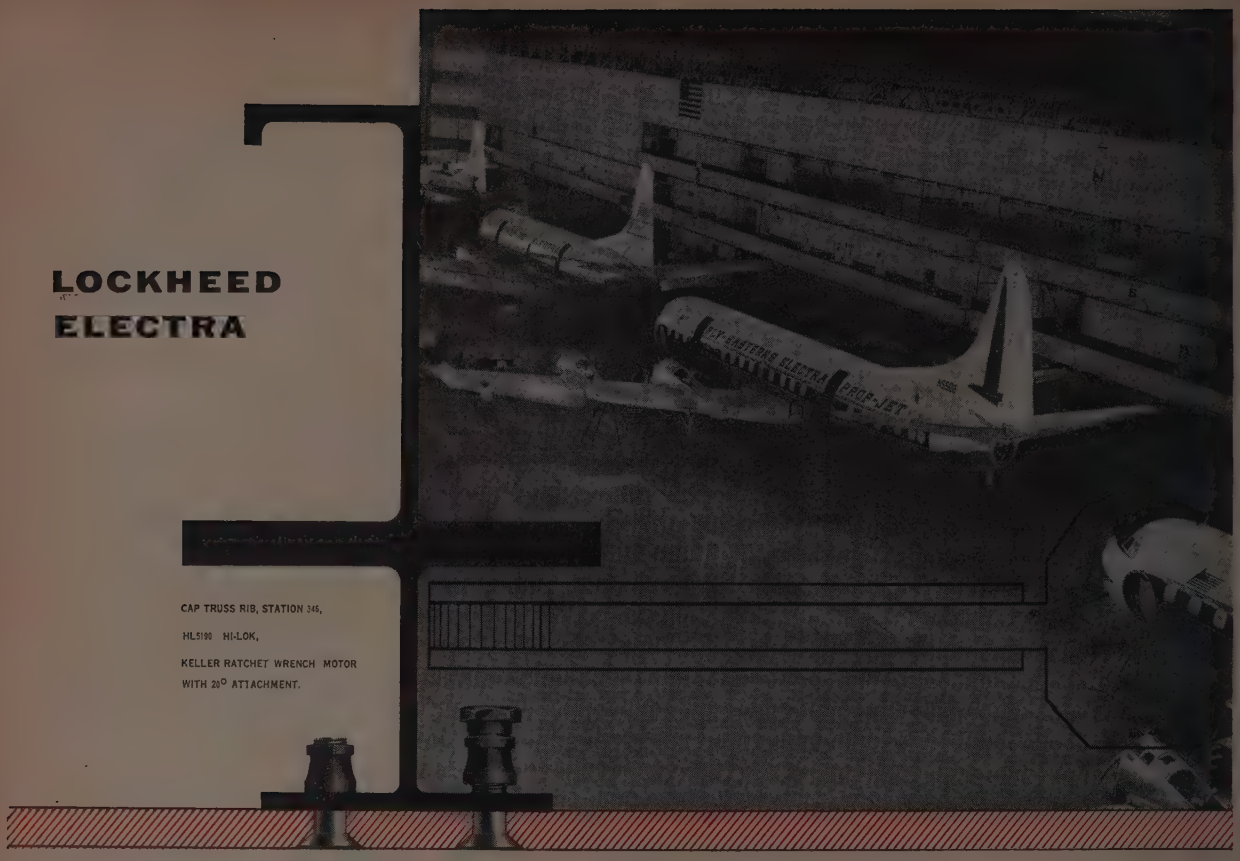
TO ACT IN CONCERT for the country's best interest—salvation and solvency —both sides must face military and economic facts. The Administration rightly is concerned with economy. Congress rightly is alarmed about security. To get the best of both economy and military security, each side must compromise.

Inflation is a growing danger. If this is accepted, then the total federal budget must be held at its present level.

Our security is deteriorating. Congress, if it believes this, must take a hard look at its welfare spending programs. These must be cut back. It must take a hard look at legislation and practices that cut down the effectiveness of our free enterprise system. For it is that which provides the jobs and products our economy needs, and weapons for our defense.

Effective security and economy for all then will be possible.

Randolph Hawthorne, Editor



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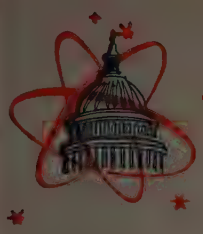

washington briefing

by **A. N. Wecksler,** Washington Bureau Chief

What do we know about the Soviet punch?

WHAT do we know about the Soviets, and how good is this information? These are the questions that come to the fore in measuring our progress against that of the Russians.

With Congress in the process of doling out $45.8 billions for "major national security" for fiscal 1960 (between $41 and $42 billion for the Department of Defense), the pressures are on from all quarters to make an all-out effort to exceed the Soviets.

There are some hard facts available: Rocket shots show the Soviets have engines of much greater thrust than we do; the Soviets have advanced guidance systems, having made great strides in long-range radars.

The problem, however, is not so much to match what the Soviets have been able to assemble as it is to get where they are going ahead of them.

In some instances, we have overestimated the Soviet potential—as is clear from the down-grading of the estimates at a later date. Examples include Secretary of Defense Neil H. McElroy's announcement cutting down the estimates of Soviet production of the Bison B-52 equivalent and the reduction in the long-standing estimate of Russian subs from 500 to 450.

Another instance where we overestimated Soviet capability was in production of ICBMs, on the basis of information a year ago that they were in actual production. Our information now is that their lead in this field is nominal, if not marginal.

On the other hand, our intelligence in the past has been more prone to underestimate Soviet strength.

The Soviets' ability to commit large numbers of MiG-15s in Korea came as a shock as did the flight of large formations of Bisons and Badgers (B-47 equivalents) in 1955. But the Prime shocker was Sputnik I, even though a Rand report had predicted the time of its launching. Sputnik III, with its ton payload, was no less of a surprise —indicating as it did the development of heavier boosters than we possess even now.

These surprises are not the last. There are reports that the Soviets have flown the Bounder, a Mach 3 aircraft that would be equivalent to the B-70, due to be test-flown in July 1961.

While there are no hard facts on whether the Soviets have launched either Regulus or Polaris-type missiles from subs, subs with "suspicious-looking cans" have been sighted in Pacific waters.

As between the cases in which we have fallen short in our estimates and those in which we have credited the Soviets with more than they had, the only clear moral is that information and intelligence are never certain.

Our system of gathering information is highly organized—with the experience of Nazi Germany and the vaunted British intelligence as guide posts. Both the British and the Germans had brilliant successes, and startling failures. German failures were in great part traceable to a lack of communication between the many agencies gathering information.

On this score, there hasn't been great criticism of our own intelligence gathering. There has been repeated assurance that information flows freely among the intelligence branches of the three military services—and presumably the Central Intelligence Agency is a constant link in the flow. The State Department, with its many ambassadorial listening posts, feeds into the stream of information, with the air attaches a clear and well-recognized source.

But it isn't the data or raw information that is significant. It's the end product—sifting the real from the phony, piecing together information that comes from unrelated sources. Finally one item of information proves up another and makes it a piece of "intelligence".

There is still a prime link. Senator Stuart Symington (D., Mo.), former Secretary of the Air Force and a member of the Senate Armed Services Committee, points it up by explaining that final verification makes fact out of intelligence. This step in the past has often come too late—and so we are working in a cloak-and-dagger atmosphere, not in textbook reality.

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industry viewpoint

by **Robert M. Loebelson,** Associate Editor

System manager needed for space program

IS THE U.S. spending too much or too little on military space projects? Dr. Ruben F. Mettler, executive vice president of Space Technology Laboratories, Los Angeles, believes there is only one way to get the answer.

"We must stop thinking of space programs per se," he declares. "We must think in terms of the missions to be accomplished. Once we analyze the objectives, space requirements will fall into place. After all," he adds, "a space vehicle is not necessarily the best way of accomplishing an air defense, strategic deterrence, or transport objective. More conventional methods might prove more effective and less costly."

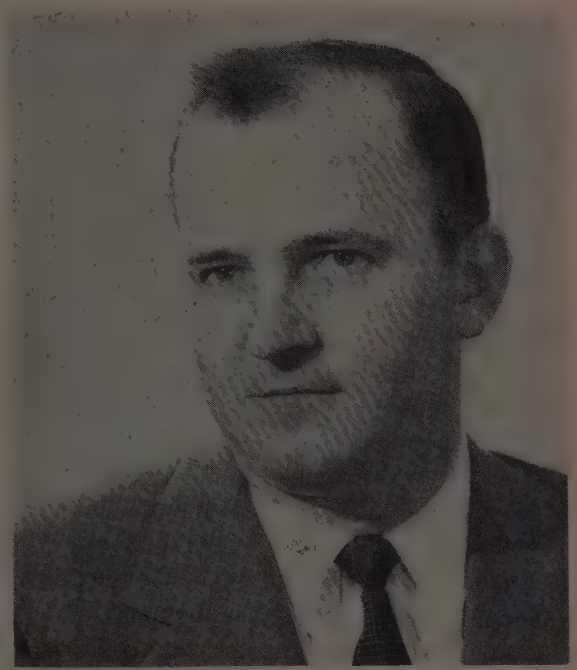
Dr. Mettler, whose organization monitors USAF's ballistic missile programs, thinks there is a tendency on the part of the public, Congress, and even the military services to think of military space projects as merely an extension of existing land, sea, and air programs.

"This point of view," according to Dr. Mettler, "may slow down our space progress."

The STL executive agrees that military space operations are logical extensions of existing Army, Navy, and Air Force activities. "But," he adds, "that is why it is absolutely necessary to have a system manager to coordinate all of our military space activities.

"We have successfully coordinated our ballistic missile program. There is no reason why we can't do the same with space. If there is too much delay, we are in danger of putting too much emphasis on certain space projects."

The STL executive concedes that integration of the military space program will not be easy. "Under our budgetary processes, it seems easier to separate space programs from other activities. And the creation of several Government agencies with space responsibilities makes the problem even more difficult."

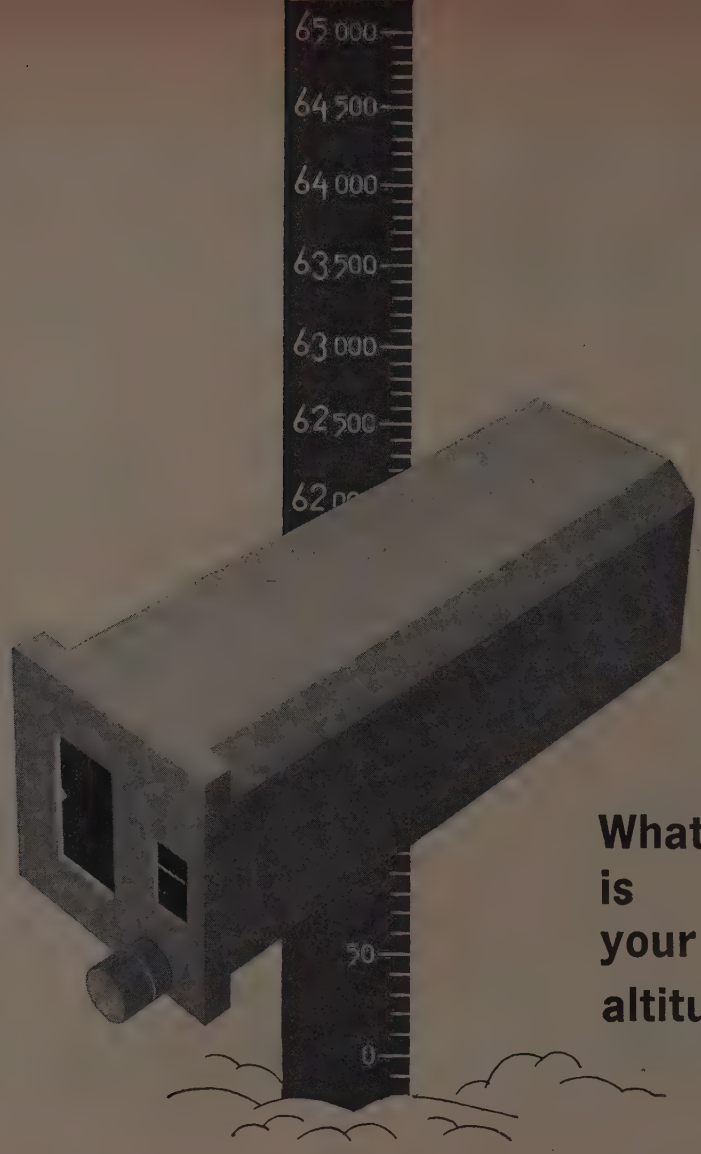


DR. RUBEN F. METTLER, Executive Vice President, Space Technology Laboratories

Dr. Mettler thinks the integrated approach isn't needed by the National Aeronautics & Space Administration. "NASA's prime responsibility is scientific exploration. They are seeking information."

Nevertheless, the STL official does not believe that coordination should be limited to military space projects.

"For systems that have an important national objective — improved communications, for example—the best approach would be to put the program under the control of a strong management organization. It would be wrong to put a heavy investment into a communications satellite without first building up the necessary ground facilities to receive messages. Yet such a satellite would be a tremendous improvement over our present communications system. One satellite over the North Atlantic would have more capacity than all the cables now linking us with Europe."



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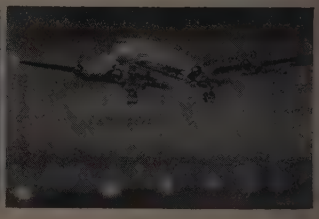

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TUG-OF-WAR for control of the military R&D program is underway in the Pentagon. The contenders: Dr. Herbert F. York, Roy Johnson, and William Holaday.

Now that Dr. York's charter as Director of Defense Research & Engineering has been issued, it seems to give him unquestioned authority over all R&D activities. But Defense Secretary McElroy's own statements about the roles of the other two men seem to conflict with the charter.

DR. YORK, according to his office's charter from DOD, is to be "the principal adviser and staff assistant to the Secretary of Defense" in the fields of "scientific and technical matters; basic and applied research; research, development, test and evaluation of weapons, weapons systems and defense materiel; and design and engineering for suitability, producibility, reliability, maintainability and materials conservation." He was also given administrative direction of the Weapons System Evaluation Group.

On the other hand, McElroy has indicated that ARPA Director Roy Johnson will report directly to him "administratively." At the same time, ARPA's research programs, according to McElroy, "are subject to the supervision and coordination of Dr. York's office, just as are those of the military departments."

Holaday remains as special assistant and advisor to McElroy

THE ROLE OF HOLADAY is somewhat confusing. He has given up the post of Director of Guided Missiles, but he remains at the Pentagon as chairman of the Civilian-Military Liaison Committee supposed to iron out differences between NASA and ARPA. Holaday therefore remains a key adviser to McElroy on missile and space programs—roughly the same area assigned to York and Johnson.

As McElroy explains Holaday's assignment, Holaday will continue as a special assistant "to handle those special aspects of the program which are beyond the research, engineering and testing phases."

COMPLICATING the situation even more are several top men in the military R&D program. The Air Force has had an Assistant R&D secretary—Richard Horner—for several years. His opposite number in the Army—Dr. William H. Martin—is Director of Army R&D but is not on the assistant secretary level.

The Navy, whose R&D activities were formerly assigned to the Assistant Navy Secretary for Air, has abolished that job in accordance with the '58 Reorganization Act. But a new post, Assistant Secretary of the Navy for R&D, has been created. How all these people will mesh their activities with ARPA and Dr. York is still to be worked out.

Skifter's position under York challenges ARPA

EVEN within Dr. York's office, a hierarchy is being created. Dr. Hector R. Skifter, on leave as president of Airborne Instruments Lab, is Assistant Director of Defense Research & Engineering for Air Defense. There will undoubtedly be other assistant directors who will carve up the space/-aero field.

Dr. Skifter's selection is a challenge to ARPA, originally set up to monitor the military space program and the problems of air defense. His responsibility is "the technical evaluation and integration of defensive weapon systems with their control environment, including anti-aircraft and anti-missile missiles and interceptor aircraft."

•

AIR FORCE has reached a major milestone in its ballistic missile procurement program—the first fixed-price, incentive-type contract. Until now, contracts awarded by AMC's Ballistic Missiles Center for airframes and subsystems were cost-plus-fixed-fee (CPFF) types in the R&D area.

But USAF has always considered the CPFF award not too desirable for the long run. It has wanted to let contracts that reward exceptional performance and penalize failures to perform as expected.

More incentive contracts on ballistic missiles will follow, USAF hopes

AMC NOW HAS WORKED OUT a $25 million contract for Thor IRBM liquid propellant engines, to be produced at Rocketdyne's Neosho, Mo., plant. This fixed-price incentive contract, USAF hopes, will be the forerunner of many others on the Atlas, Titan, Thor, and Minuteman programs.

more on next page

U.S. RENEGOTIATION BOARD, trying to recapture large sums earned by the space/aero industry in '53-'55 that it believes were "excessive," is certain to have its life extended beyond the present expiration date of June 30. But there may be some changes that will give industry firms a better break.

One proposal to liberalize the Renegotiation Act has come from Rep. Cecil King (D., Calif.), who wants the law extended to June 30, '61. His H.R. 5123 would tell the Renegotiation Board to consider these factors, among others, before concluding that a company's profits in a given year were excessive:

- the company's efficiency in getting the job done;
- its net worth (with special regard to the amount and source of its public and private capital);
- the extent of the risk assumed by the company;
- the nature and extent of the product's contribution to the defense effort;
- the need for financial stability of defense contractors;
- the need for proper incentives.

KING is also proposing a special rule under which a 10 per cent increase over the agreed rate of profit would not be considered excessive by the Renegotiation Board. His measure also provides that contractors who feel Board rulings are unfair may appeal them to the U.S. Tax Court.

$18.5 million spent on Plato, now "temporarily" dropped

AIR DEFENSE MISSILES account for the bulk of the Army's missile spending scheduled for fiscal '60. Accumulated planned obligations through '60 for these missiles are: Nike-Ajax (already obsolete), $1,257,400,000; Nike- Hercules, $1,882,-800,000; Nike-Zeus (still in development), $591.5 million; Hawk, $566.6 million.

Another air-defense missile, the Sylvania Electric Plato, designed to provide a ballistic missile defense for battlefield troops in conjunction with the Zeus, has been dropped "for the time being" after an expenditure of $18.5 million.

PLANNED OBLIGATIONS through '60 for other Army missiles include: Redstone, $513.2 million; Corporal, $286.3 million; Sergeant, $257.7 million; Lacrosse, $270.9 million; Honest John, $250.5 million; Little John, $6.5 million.

CRITERIA used by Pentagon to determine which weapon systems should be continued and which cut back in '60 have been revealed. W. J. McNeil, Assistant Defense Secretary (Comptroller), says DOD planners worked on the following basis:

- On programs considered essential, the rate of development was ordered maintained and even increased if this seemed technologically feasible.
- On programs that seemed of lesser importance or had been overtaken by new projects, the level of effort was either reduced or the programs were eliminated entirely.

DOD missile spending to reach high of 27 per cent in fiscal '60

AS A RESULT of these evaluations, McNeil reports, aircraft purchases will account for 45 cents of the DOD procurement dollar in fiscal '60. The missile slice will reach an all-time high of 27 cents. In fiscal '57, missiles represented 15 and aircraft 58 per cent of DOD's hardware spending.

Despite the changing "mix" of military weapons, McNeil says employment in the space/aero industry will probably remain unchanged through fiscal '60.

•

TWO-THIRDS of the scientists and engineers employed by the space/aero industry are engaged in R&D work—a higher percentage than in any other major manufacturing group. A survey conducted by the National Science Foundation (covering '54-'56) also indicates that 62 per cent of the industry's technicians are involved in R&D projects.

During the period covered, the industry employed a total of 84,900 scientists and engineers and an additional 51,500 technicians. It increased the number of scientists and engineers on its payrolls by 75 per cent (as against an increase for all U.S. industry of 30 per cent). The increase for R&D was even sharper: Between early '54 and early '57, the number of scientists assigned to R&D jumped by 105 per cent.

ADVOCATES of more basic research now have a new legislative proposal to support: Rep. Thomas B. Curtis (R., Mo.) introduced H.R. 4797, which would encourage basic research by granting tax credits to universities and industrial organizations engaged in it.

Curtis' bill, which has been referred to the

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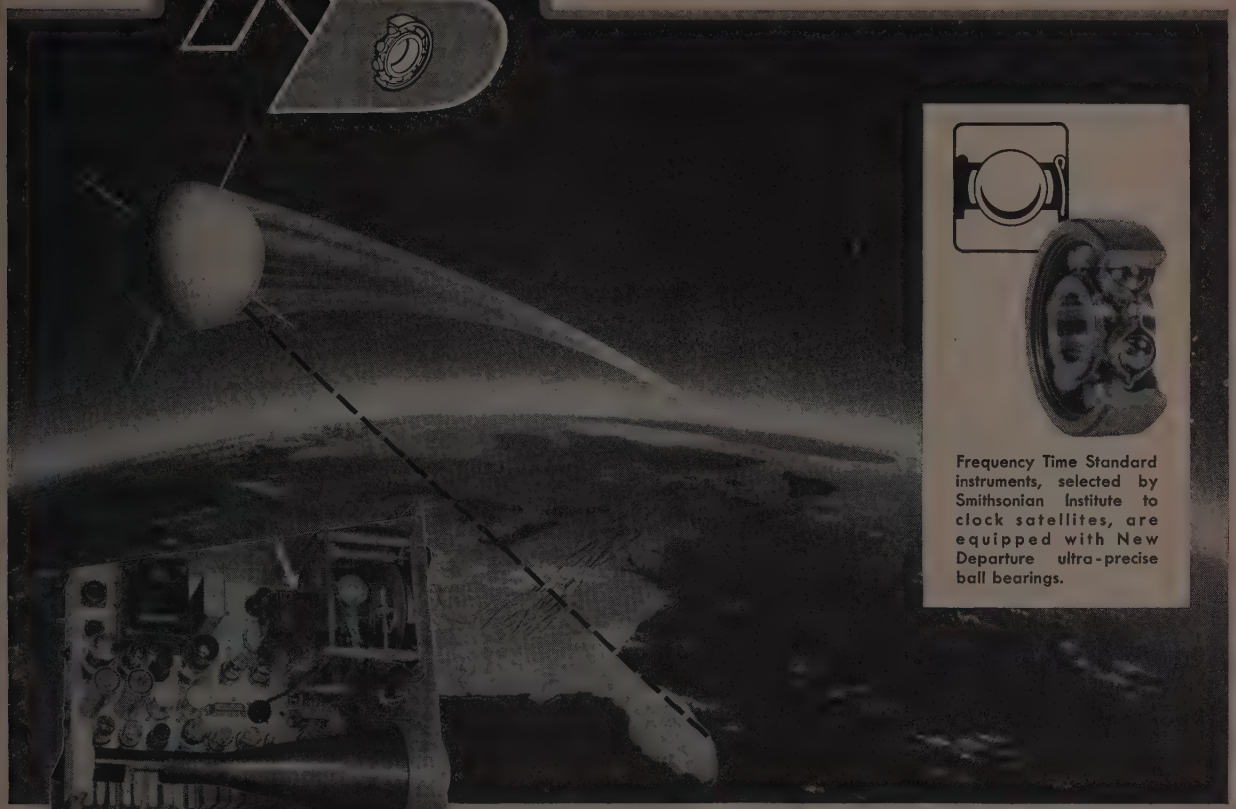
CASE HISTORIES



Frequency Time Standard instruments, selected by Smithsonian Institute to clock satellites, are equipped with New Departure ultra-precise ball bearings.

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House Ways and Means Committee, provides up to 90 per cent of the basic research cost in the case of non-profit institutions. Industry research would be covered up to 75 per cent. Sums credited would be limited to five per cent of the tax normally imposed on the non-profit institution and three per cent of that normally paid by a company.

The non-profit institutions themselves would determine which basic studies would be eligible for the tax credits. In the case of industry, a board of scientists named by the President would rule on this point.

ANOTHER APPROACH to the same problem is being taken in a measure introduced by Rep. Overton Brooks (D., La.). His "tithe for science" bill provides that, whenever a Government R&D contract is let, 10 per cent of it would be set aside for basic studies.

Under Brooks' proposal, which is limited to contracts exceeding $10,000, the cost of basic research done by a company could be charged against the gross profits on R&D contracts. One big advantage of this is that renegotiation problems would be reduced.

New missile obligations rely heavily on "unwanted" funds from last fall

UNWITTINGLY or otherwise, the Defense Department handed Congress ammunition to go beyond President Eisenhower's budget request for the coming fiscal year. Democratic leaders, who have expressed concern about inadequate funds, will now be able to intensify criticism of the Budget Bureau and the President for not spending the additional funds voted last year.

In a document outlining planned missile obligations for the next year, DOD indicated a heavy reliance on the "unwanted" funds provided last fall.

Missile obligations (including Polaris subs) for fiscal '60 total $6.817 billion, down about $400 million from the $7.212 billion projected for '59. The total for '60, however, includes the $6.379 billion sought in the January budget message as well as $438 million from last year's "unwanted" money.

•

CLARIFICATION of military ground support equipment development responsibilities might help straighten out a muddle in which aircraft carriers have at times been claimed as part of GSE. Army Corps of Engineers now is the primary construction agency for ICBM-IRBM missile facilities, whose overall design is under the jurisdiction of AF's Ballistic Missile Div.

According to a spokesman of the Los Angeles Engineer District, the Corps of Engineers is responsible for the "brick and mortar" aspects of the missile launching facilities and for refinements in instrumentation installed by missile contractors. "Brick and mortar," he said, includes such items as process piping, pressure vessels, control mechanisms and consoles, special valving, some intrumentation, flame deflector, deluge systems, service towers, and tailored structures to house the special impedimenta of a launching complex.

Better definitions needed for standardizing of GSE

WEAPON SYSTEM PROGRAMS and engineers might be helped if there were a clear-cut definition of what should be considered GSE and how many types of GSE systems are needed. Proposal has been made that basic GSE be broadly grouped as either R&D or operational. In each area, it should then be broken down into standard and non-standard system equipment, subsystem equipment, and component equipment, as applicable.

GSE facilities for a specific weapon system would be broken down into standard and non-standard operational, test, and servicing systems.

AGREEMENT on what should be considered GSE and what shouldn't would go a long way toward cutting down wild engineering estimates of development costs. It would also make it easier to "standardize" on the design of "repeat" items—used for more than one weapon system with less than 10 per cent modification.

Example of standardization is Titan facility being built at Vandenberg AFB. It has the same basic components as the Atlas and Thor facilities but is being built almost completely underground.

■

LOCKHEED set up an Electronics Division at Maywood, Calif., under Dr. Louis Ridenour. According to president Robert Gross, Lockheed did some $30 million work of electronic design and fabrication under its own roof last year, all as part of its missile and aircraft work.

The new division expects to sell its products to all phases of the industry and not just to Lockheed alone.

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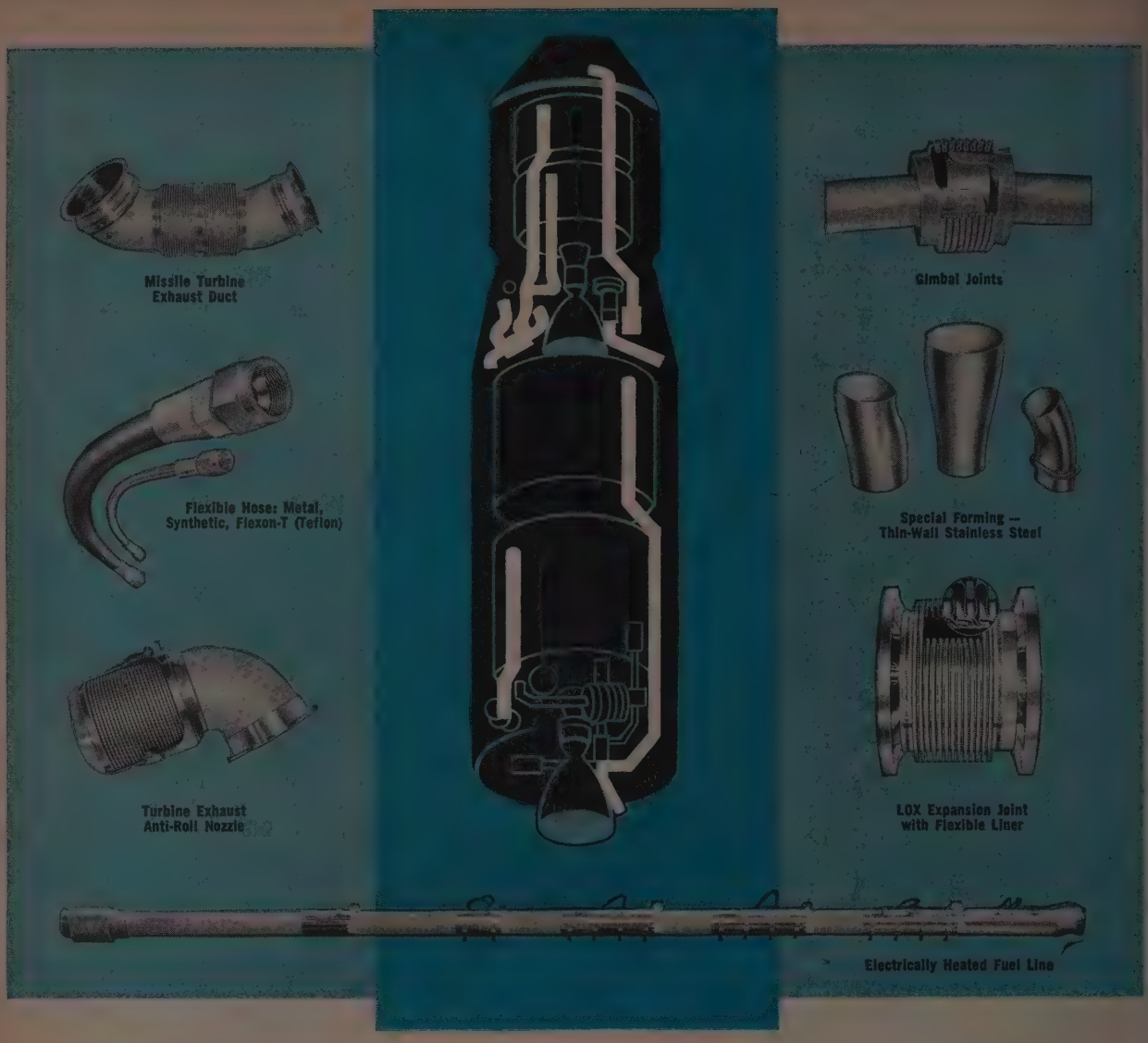
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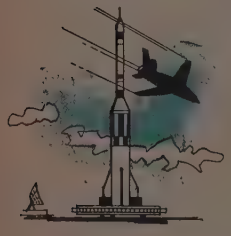

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GSE FOR TACTICAL MISSILES is definitely going from current "movable" systems to completely mobile ones, H. R. Hammond, of Food Machinery & Chemical, told recent ASME Aviation Conference in Los Angeles, Sergeant support system, for instance, will use 3-4 tank-propelled vehicles for quick movement over rough terrain. Typical communication vehicle would weigh 13,000 lb, be transportable in C-123B; missile transporter-erector would weigh 17,000 lb, fit in C-130.

Reason for these trends, states Hammond, are new developments in big wheels and new types of tank tracks Wheels 12-18 ft in diameter and four feet wide have been devised, while Space link tracks permit movement of vehicles even over bogs, such as Alaskan muskegs.

Booster recovery should cut cost of satellites

RECOVERING large boosters is a key factor in expected reduction from initial $1,000,000 per pound of payload placed in orbit in '57 to $100 per pound by late '60, H. H. Koelle, chief of Future Projects Design Branch at ABMA's Structures & Mechanics Lab., told ASME Conference. Possible recovery systems include (1) rocket booster with wings and control surfaces and (2) parachutes combined with brake rockets.

•

PROPULSION NEEDS for space station erection indicate storable, hypergolic, liquid propellant systems are best, J. A. Bottorf and H. B. Ellis, of Aerojet-General, told ASME. Hypergolicity is needed for safety, reliability in thrust chamber operation, and simplier system design (by elimination of ignition systems). This concept also calls for operation at ultra-low combustion pressures of only 5-10 psia.

Missiles and their GSE must meet airlift requirements

AIRLIFTING OF MISSILES is becoming an increasingly important part of USAF transportation needs, R. E. Flanigan, AF systems management engineer, told ASME. Air transport, he states, increases missile reliability as well as mobility, since it permits movement with minimum handling, reduced shock, controlled environment, etc. Designers must place greater emphasis—in designing both missiles and GSE—on loading capabilities, limits of available cargo planes, securing methods, etc.

YTTRIUM has been produced in pliant, easily fabricated form by Bureau of Mines metallurgists. Up to now, yttrium has always been considered too brittle for structural uses. New development may permit its use in atomic reactors and missiles. High purity yttrium made by the bureau contains only about 0.02 per cent oxygen, which is the embrittling element that till now has made yttrium impractical, even though the metal has a melting point of around 2800 deg F (near that of carbon steel).

Argus explosions raise problems of communications and countermeasure design

RESULTS OF 300-MILE-HIGH nuclear explosions during Project Argus experiments indicate that (1) at that altitude effects of such blasts are felt globally within an hour, (2) electronic particle dispersions interfere in varying degree with some radar frequencies, (3) radio communications are likely to be disrupted, but "certain" frequencies are not seriously affected, (4) neutrons released by the explosion (and constrained by the earth's magnetic field) could be counted on to detonate nearby armed nuclear warheads.

PROJECT ARGUS triggered three nuclear explosions in the South Atlantic early last September. Force of each reported to have been in the kiloton range.

Monitoring plans called for two satellites to blanket the space belt before, during, and after the explosions, so that contours and effects of spreading radiation could be mapped.

Satellites were Explorer IV, which was successfully launched last July 26 from Cape Canaveral, and Explorer V, which was launched on August 24 but never got into its nearly polar orbit. Test results therefore are not as conclusive or revealing as had been hoped. This is why it is expected more experiments will be carried out—perhaps in 100-mile increments out to 1500 miles from earth's surface.

GRAVITY THEORY developed by Prof. Paul A. M. Dirac, of Cambridge U., says gravity exists in energized wave form. At the recent American Physical Society meeting in New York, the British physicist mathematically demonstrated that a moving mass should generate gravitational waves much as a moving electrical body produces elec-

more on next page

tromagnetic waves. According to his theory, the resulting gravitational field created carries energy away from the moving mass.

GRAVITATIONAL WAVES are very weak compared with ordinary electromagnetic waves which are 10^{40} times stronger, says Prof. Dirac. But since waves are usually multiplied by enormous masses—such as the earth's—the gravitational force is nevertheless appreciable.

The gravitational wave units, called "gravitons" by Prof. Dirac, cannot be detected by present experimental techniques. But, if they do carry energy physicists are confident a practical means of detection will be developed.

Forward ports in second stage control cutoff of Polaris thrust

POLARIS THRUST CUTOFF is controlled by opening of four forward ports in second-stage solid propellant engine. A preset integrating accelerometer ruptures frangible disks covering the ports during flight. Rearward thrust balances out any possible perturbation introduced by suddenly opened ports. Thrust is quenched within a matter of 50 milliseconds, so that terminal velocity can be controlled within 20 fps.

CONTROL TROUBLES pestering the Polaris program are believed to center about the jetavators. Their bearing surfaces become coated with exhaust products at sea level and tend to bind.

Gimbal control is being substituted in Polaris tests in hope of beating the control problem. Another approach uses nozzles that are displaced about an asymmetrical axis to vary the thrust vector.

Gas jets may also be used for attitude control Side nozzles would be used for pitch, yaw, and (to a lesser extent) roll control.

SEVERAL VERSIONS of Polaris exist. The A-version now being tested is the one with a range of about 800 miles. It contains a two-axis gyro reference system instead of the stable platform planned for the advanced B- and C-versions.

The two advanced versions each add a 10 per cent improvement in efficiency. Specific impulse of second stage is higher and new lightweight materials are used for the rocket engine cases in these models. Payload for even the C-version is said to be under 1000 lb.

MORE EFFICIENT structural design and more powerful propellant, providing better mass ratio, are expected to give B- and C-versions their biggest advantage over the "A".

Backup contract for second-stage Polaris engine is said to have been awarded to Alleghany Ballistics. Second stage is believed to be a smaller replica of the first stage.

RUMORS of polaris downgrading to 750-800 nm are untrue, Navy's Rear Adm. W. F. Raborn stated during recent Western Space Age Conference. Program is still aimed for full 1200 nm at the same target date, he emphasized.

Submarines for Polaris, Raborn stated, are being designed to take foreseeable larger missiles without major modifications.

REVOLUTION in making steel and high alloy castings has changed casting field in past 10 years, W. H. Dunn, of Pacific Alloy Engineering, El Cajon, Calif., told the Conference—but even more impressive progress is coming. Casting techniques have been perfected on AM 355, he reported, and with such other materials as Vascojet 1000, Potomic M, Rene 41, etc., now can also be cast.

Cluster of eight Jupiter engines is proposed

ABMA MULTI-CLUSTER propulsion scheme of putting together eight Jupiter engines is expected to produce a 1,500,000-lb thrust pilot engine by November. The program appears to be going along quite smoothly. Several sets of tankage have already been ordered.

The cluster would have four controllable and four fixed engines. It is expected that two of the four gimbal-controlled engines could quit without compromising the mission and that limited flight would still be possible with just one controlled engine.

EXPERIENCE shows very few rocket engine failures are explosive in nature. If one of the cluster engines failed, it is assumed the shutdown would not be catastrophic.

PROPELLANT FLOW to any of the clustered engines would be cut off immediately in case of an individual failure. Pressure, temperature, and fuel flow control sensors are all included in the "safety" circuit.

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POOR MAN'S VEHICLE for probe and satellite launchings being developed jointly by NASA and the Air Force. It will cost about $500,000 in production quantities. The four-stage Scout will be able to put a 150-lb payload into a 300-mile high orbit or send a 100-lb probe payload out to about 5000 miles.

Air Force intends to use Scout to test guidance systems and other components of advanced ballistic missiles.

SCOUT WILL USE solid propellant engines for all four stages. It will weigh about 35,000 lb and be about 70 ft long. First test firings are slated for mid-'60.

First-stage engine for Scout will be lifted from the Polaris IRBM. Second Stage will have an improved Sergeant engine, and the third- and fourth-stage powerplants will be improved Vanguard third-stage engines.

Miniature drone has interchangeable nose assemblies

SD-3 SNOOPER miniature drone, developed by Republic for the Army Signal Corps, is being flight-tested. It weighs less than 1000 lb, is about 15 ft long, and has wing span of 11 ft. It is to be used for battlefield surveillance of enemy troop movements, fortifications, and depot installations.

Interchangeable nose units provide a choice of surveillance techniques—photography, infrared, radar, or television. Missions can be programmed in advance or controlled from a ground monitoring station.

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MOST ADVANCED meteorological satellite experiment planned so far is scheduled for launching late this year. The satellite will carry 1-3 miniature TV cameras to photograph cloud coverage. Definition is expected to be far better than that of Vanguard II's photoelectric cells. Infrared optics may also be included to determine cloud coverage at night.

PROOF that solid propellant rockets that have been stored for extended periods can be fired successfully comes from Astrodyne. The company's producer, which delivers about 250,000 lb thrust for a few seconds, was test-fired after being stored for a year at 170 deg. It can be used as a booster for missiles, for high-speed track operations, and for zero-launchings of large planes.

VARIABLE-SPEED, constant-frequency (VSCF) electric generator system developments have reached the hardware stage. Both Jack & Heintz (see *"Variable-Speed, Synchronous-Flux Generator Delivers 20-120 KVA," p. 50*) and Hallamore Electronics claim to be pioneers in the field of practical airborne systems.

Hallamore's VSCF consists of (1) an alternator with a polyphase field, (2) a polyphase variable frequency exciter, (3) a tachometer generator, (4) a frequency standard reference, and (5) a regulator. The only moving part consists of an integrated rotor assembly for the alternator, exciter, tachometer generator, and fan.

PRINCIPLE OF OPERATION centers on electric rotation of the magnetic field of the alternator armature at a constant velocity regardless of shaft speed. Result is a constant-frequency output.

Velocity of the magnetic field is made up of the vector sum of the mechanical velocity of the shaft and the velocity of an electromagnetically induced rotation produced by controlled excitation of a polyphase field winding. The excitation source is a variable frequency polyphase exciter whose frequency is directly proportional to the speed deviation from the "synchronous" speed of the alternator rotor.

SIXTY-KVA BRUSHLESS VSCF SYSTEM proposed by Hallamore reportedly weighs about 220 lb—about 110 lb for the alternator, 65 lb for the exciter, and 45 lb for the housing and other subassemblies. Static controls weigh about 50 lb maximum.

In the 60-kva range, the weight and volume of its brush-type VSCF system are about 10 per cent less than those of comparable hydromechanical constant-speed-drive generating systems, says Hallamore. Weight saving of the brushless design is probably a bit less, since rectifiers are used that need some cooling.

Mechanical simplicity of the VSCF system is big factor in its favor. It is estimated there are about 1000 fewer parts in the electric VSCF system than there are in a hydromechanical system.

Two radiation belts of very high intensity defined by Pioneer III

PIONEER III data, collected during the satellite's 38-hour flight, defined two radiation belts—the first roughly between 1400 and 3400 miles

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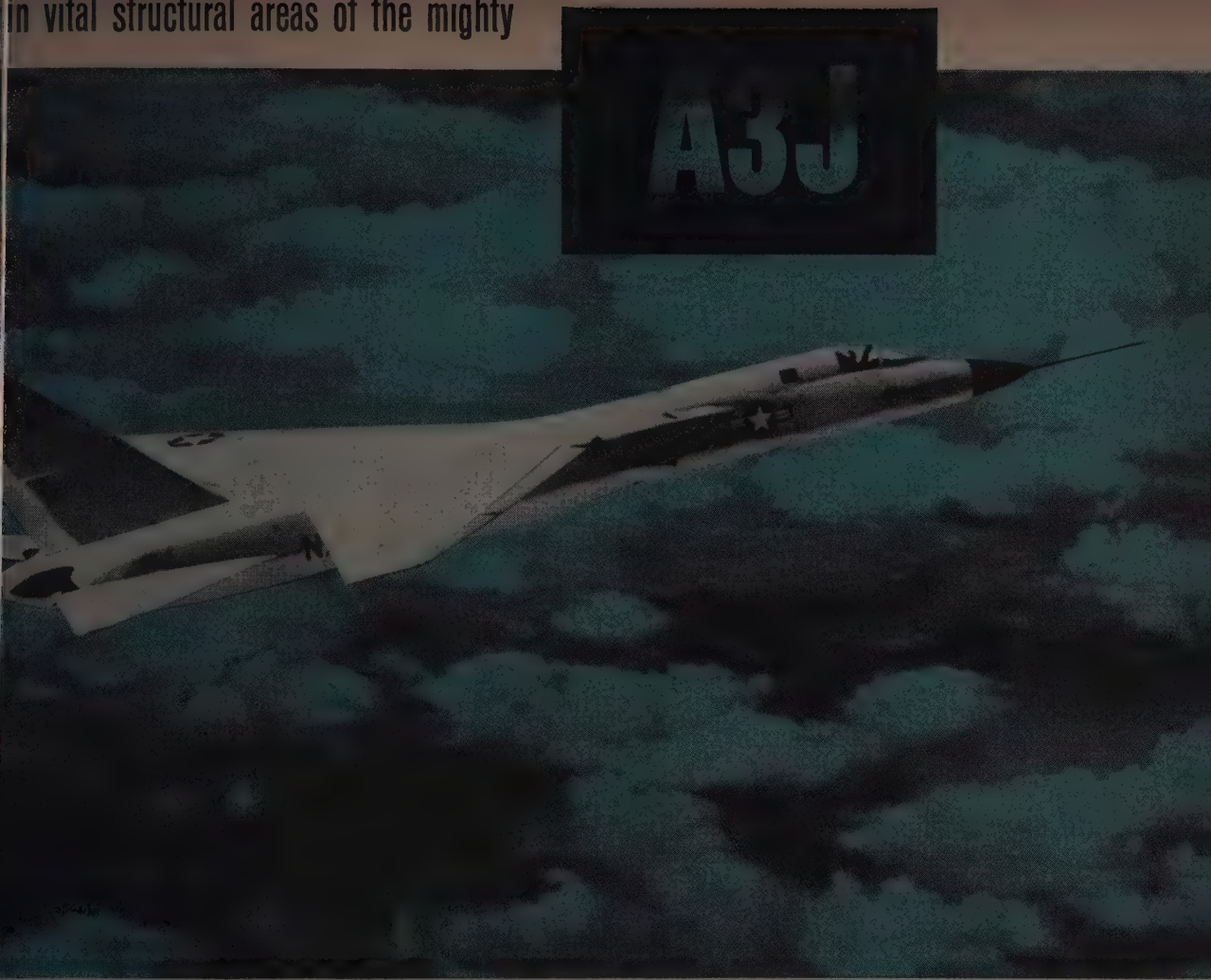
in vital structural areas of the mighty



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from the earth's surface and the second between 8000 and 12,000 miles.

Each belt has a very high intensity of charged particles. Peak is at about 2400 miles out in the first belt and about 10,000 miles out in second. High of 25,600 counts per second was registered.

THOR-ABLE space probe test firing from Cape Canaveral is scheduled for this month. Flight will be made to check out systems going into several interplanetary probes to be launched during the summer.

PRODUCTION F8U-2N CRUSADER scheduled for delivery to the fleet in early '60 will have a Chance-Vought-developed autopilot. The all-weather fighter will be powered by a P&WA J57-P-20 jet engine.

High accuracy manometer uses mercury cisterns

EXPERIMENTAL mercury manometer for calibrating pressure-sensing instruments was developed by Bureau of Standards. It is designed to measure pressures corresponding to altitudes over 60,000 ft. It uses a capacitance measurement technique to sense the height of its mercury columns. Accuracy is 0.0002 in. or better, says NBS.

THE MANOMETER consists essentially of two mercury cisterns connected by a flexible, jointed tube. One cistern is movable and connected to a known pressure, the other is fixed and is connected to the pressure to be measured.

Bottom surfaces of glass covers on both cisterns are metal-coated so that an electrostatic capacitance is formed between the top of each mercury column and the undersides of the covers. These capacitances are balanced by raising or lowering of the movable cistern. A micrometer reading showing how far the cistern moves is the pressure difference in inches of mercury.

Tests of a prototype model show that maximum error in readings is 0.00011 in. Hg. On top of this there is a systematic error in the height reading that's believed not to exceed 0.00005 in. Hg. The uncertainty is therefore taken as 0.00016 in. Hg.

•

BRISTOL SIDDELEY'S Orpheus B-Or-12 lightweight, medium thrust turbojet successfully completed its first comprehensive bench test late last year. It put out 6810 lb thrust during tests at design turbine entry temperatures. SFC proved to be considerably lower than had been predicted, says the company.

Work scheduled for coming year on the B-Or-12 includes a 150-hr type test, to be followed by a full flight testing program. At the present rate of progress, the engine could be available off the production lines by '60.

PIONEER IV sun-orbiting payload weighs 13.4 lb, about half a pound heavier than Pioneer III. Outside dimensions are about the same—20 in. length and a bit over nine inches maximum diameter.

Principal changes from Pioneer III payload include ⅛-in. thick lead shielding around one of the two Geiger-Mueller tubes for refined measurements of radiation, improvements in the de-spin device, and addition of a monitor to report on performance of the radio transmitter.

Lead shielding cuts off the detector tube from all but very high energy particles. By comparing data it reports on this flight with that from the same tube that rode unshielded in Pioneer III, researchers will get a good idea of the nature of the radiation particles.

Two tiny weights were used for Pioneer de-spinning

BASIC DE-SPIN technique was the same on Pioneers III and IV. Two tiny weights, about six grams apiece, were fastened to the payload at the end of wires about 60 in. long. During and after launch, the wires remained securely wrapped around the spinning payload. About 10 hours after launch, an hydraulic timer freed the weights and centrifugal force made them unwind. When completely unwound, wires and weights were released from the payload and flew off into space.

Release caused payload spin to slow down immediately to about nine rpm. In effect, whirling weights change the energy pattern of the payload. They extract spin energy from the cone and carry it away with them.

TRANSMITTER MONITOR was added to Pioneer IV because of the unexpectedly sharp drop loss in radio signal strength on Pioneer III. The monitor will help determine whether the loss was caused by equipment weaknesses or by some condition in space that's not yet understood.

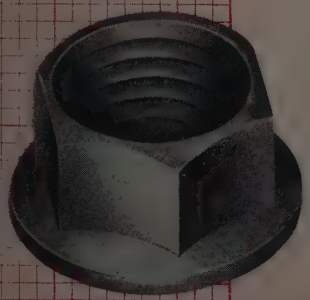
OPTICAL MOON TRIGGER aboard Pioneer IV never got tested, since the trajectory fell far short of a moon intercept. The unit consists of a pistol-shaped photoelectric sensor with a lens in the barrel. Two apertures behind the lens are connected so that only a light image large enough to cover both will activate the shutter.

Again...

ESNA gives the design decision to the engineer

If your major consideration is...

...WEIGHT REDUCTION



Type LH3324 (160,000 psi)

THIS NEW DESIGN is ESNA's recommendation for applications where space and weight reduction are primary needs. Meets MIL-N-25027; reduced wrenching dimensions permit more efficient centerline bolt design; wrench heights carefully engineered to assure satisfactory assembly line performance. Materials: carbon steel, AMS6304 alloy steel and A286 stainless steel.

wt in lbs per 1000	Screw Size # 4	# 6	# 8	# 10	¼"	5/16"	3/8"	tensile rating
LH3324	.2	.6	1.3	1.4	2.9	5.4	7.3	160,000 psi
NAS679	.9	1.7	2.4	2.6	4.6	6.4	8.6	140,000 psi
AN365	1.4	2.6	4.2	5.0	9.0	12.0	18.0	140,000 psi

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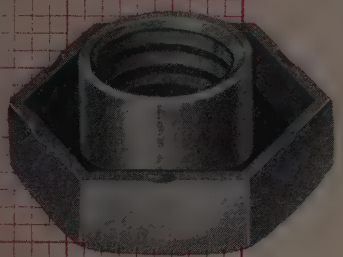

Type LHTE-TM (NAS 679 140,000 psi)

This complete line of low-height, lightweight NAS 679 hex nuts has been designed and produced to ESNA's exacting quality standards. Qualified to MIL-N-25027. External-internal wrenching surfaces for easy installation in limited access areas. Sizes 4-40 through 7/16-20. Alloy steel for temperatures to 550°F; A286 stainless steel for temperatures to 900°F and nonmagnetic applications.

ESNA offers a complete line of ALL NAS types of self-locking nuts, including standard and miniature anchors, floaters and gang channels.

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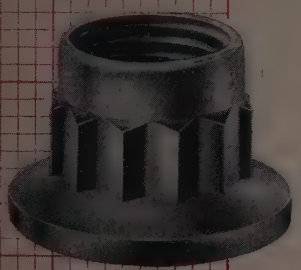

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Other lightweight 12 point nut series are available in several tensile capacities and materials for service at temperatures to 1300°F.

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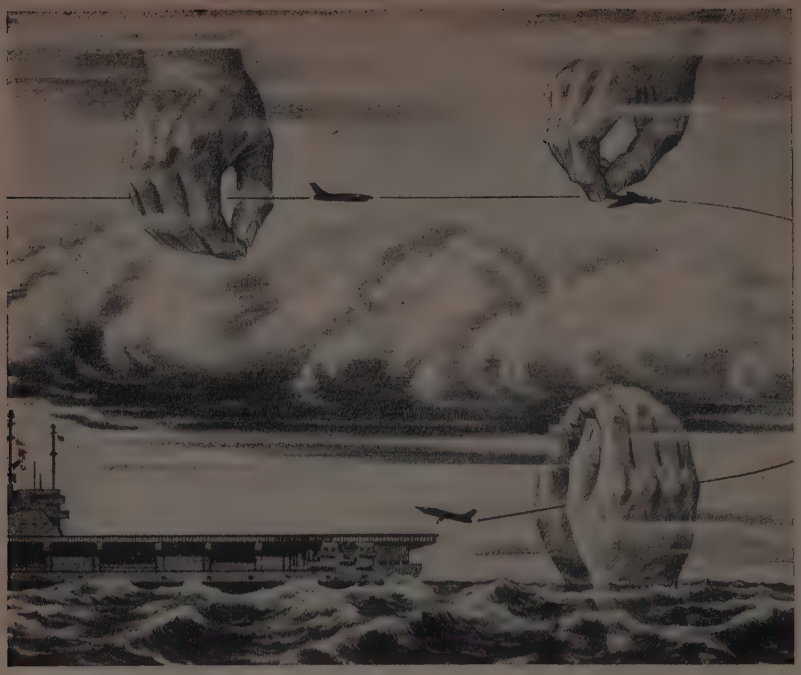

Cornell Aeronautical Laboratory and . . .

ALL-WEATHER
RETURN-TO-CARRIER FLIGHT

A hundred jet aircraft scream toward their distant carrier. Some are disabled; others, critically low on fuel. Their landing must be swift; timed to the second. This systems problem was assigned to Cornell Aeronautical Laboratory scientists and engineers by the Bureau of Ships seven years ago. Project name: PACO — Problems of All-Weather Carrier Operations.

In order to link the carrier to the flight group beyond the horizon . . . establish mutually compatible flight paths . . . control an efficient landing sequence (with provision for emergency landings and wave-offs) . . . and to land the planes automatically on an unstable deck, electronics in every conceivable form has been focused on the problem.

Systems engineering, traffic control philosophy and the inter-relation of aerodynamics and electronics all play a part in the systems design and experimental support work of C.A.L.'s project team. Their efforts have resulted in significant contributions to equipment development including TACAN, Data Link and Traffic Control Computer, Transition and Wave-Off Computer, and Automatic Landing System with Deck Motion Predictor.

PACO typifies the broad scope and professional maturity of research projects at C.A.L. If you are interested in becoming a member of one of our small, closely-knit research teams, write today for the factual, well illustrated, 68-page report entitled, "A Decade of Research." Mail the coupon now for your free copy.

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calendar

April 5-10—1959 Nuclear Congress, Municipal Auditorium, Cleveland, Ohio. Data—Engineers Joint Council, 29 West 39th St., New York 18, N. Y.

April 6-7—Second National Symposium on Chemical & Petroleum Instrumentation, Instrument Society of America, St. Louis, Missouri.

April 6-8—Fifth National Military-Industrial Conf., Palmer House, Chicago, Ill.

April 7-10—"The Effect of Numerically Controlled Machines of Engineering, Production, and Management Philosophy", Memorial Center, Purdue Campus, West Lafayette, Indiana.

April 12-16—International Conf. on Fracture, Massachusetts Institute of Technology, Air Force Office of Scientific Research, Office of Naval Research, National Science Foundation, National Academy of Sciences, Cambridge, Mass.

April 12-19—Air Force Assn's World Congress of Flight, Las Vegas, Nevada.

April 16-18—11th Annual Southwestern Institute of Radio Engineers Conf. and Electronics Show, Dallas Memorial Aud., Dallas, Tex.

April 18-22—American Society of Tool Engineers Annual Meeting, Schroeder Hotel, Milwaukee, Wisc.

April 21—Material Handling Institute, Membership and Directors Meetings, Sheraton-Cleveland Hotel, Cleveland, Ohio.

April 21-22—Spring Technical Conf. on Electronic Data Processing, Cincinnati Section of the IRE, Engineering Society Bldg., Cincinnati, Ohio.

April 22-24—1959 Annual Meeting, Institute of Environmental Engineers, LaSalle Hotel, Chic., Ill.

April 30-May 1—Controllable Satellites Conf., American Rocket Society, MIT, Cambridge, Mass.

May 3-7—115th National Meeting, Electrochemical Society, Sheraton Hotel, Philadelphia, Pa.

May 4-6—National Aeronautical Electronic Conf., IRE & IAS, Biltmore Hotel, Dayton, Ohio.

May 4-7—Fifth Annual Flight Test Instrumentation Symposium, ISA, Seattle Section, Olympic Hotel, Seattle, Wash.

May 6-8—Seventh Regional Conf. and Trade Show, IRE, Univ. of New Mexico, Albuquerque, N. M.

May 6-8—1959 Electronic Components Conf. IRE, Electronic Industries Assn., American Institute of Electrical Engineers, West Coast Electronic Manufacturers Assn., Benjamin Franklin Hotel, Philadelphia, Pa.

May 11-13—National Power Instrumentation Symposium, ISA, Kansas City, Kansas.

May 11-15—Joint Meeting of the AGARD Aeromedical and Flight Test Techniques and Instrumentation Panels, Athens, Greece.

May 17-19—Fifth National Symposium on Instrumental Methods of Analysis, ISA, Shamrock-Hilton, Houston, Texas.

May 18-21—18th Annual National Conf., Society of Aeronautical Weight Engineers, Hotel Henry Grady, Atlanta, Georgia.

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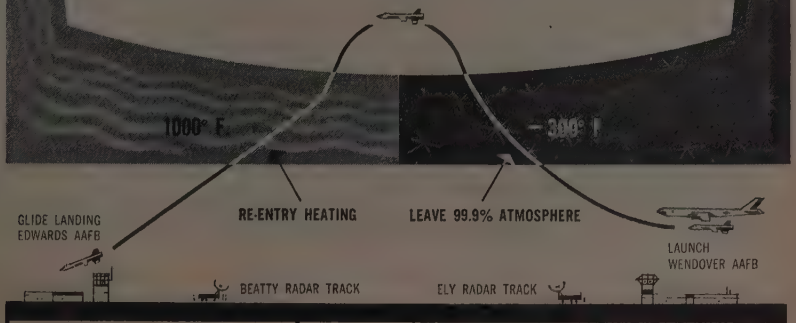
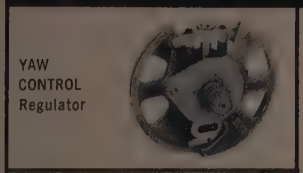
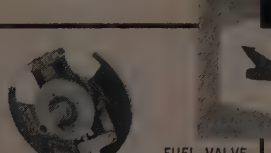
fly with the X-15 into space







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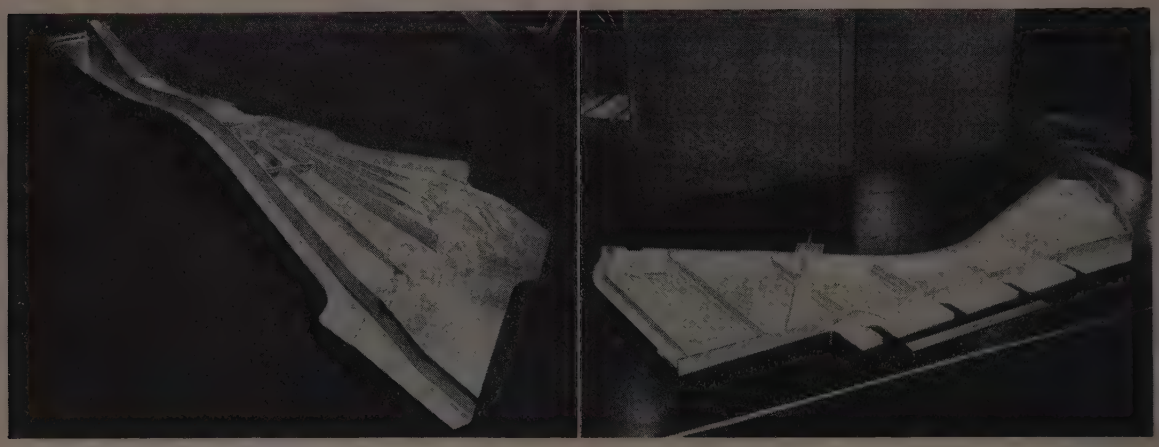


TYPICAL PARTS now produced in quantity by numerical control and suitable for production by "automatically programed tool" (APT) system (from left to right): wing spar cap for Republic F-105 fighter, splice vent fittings

Automatic programing

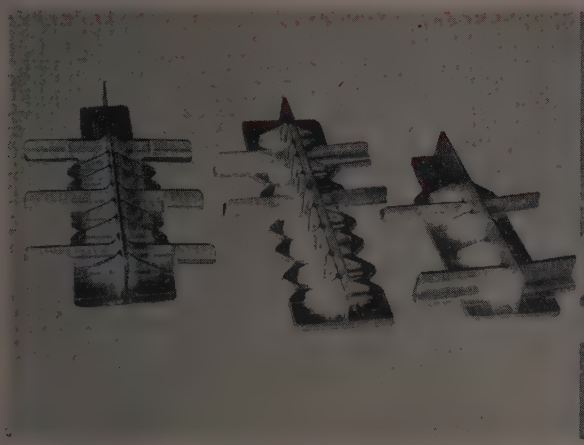
fits automation to new production needs

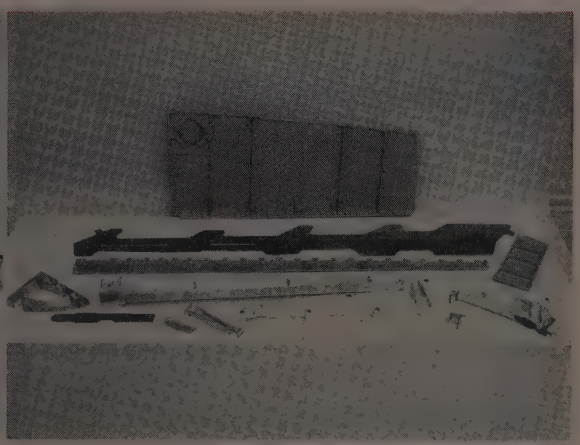
Automated, or numerically controlled, machine tools are nothing new. But they still rely on human beings for programing—a lengthy and complex job. Soon, however, programing may become almost as automatic as the fabrication process itself, solving a critical production problem in the space/aero industry.

by Robert M. Loebelson Associate Editor

TECHNICAL MANAGEMENT in the space/aero industry has been presented with a new and improved method of producing aircraft and missile parts. The new technique is the result of nearly a decade of combined effort by the Aircraft Industries Association, Air Material Commend's Manufacturing Methods Division, and MIT's Servomechanism Lab.

Known as APT (Automatically Programed Tool), the system uses a high speed digital computer to replace men and desk computers in calculating the data needed to program the motions of a numerically controlled machine tool to cut metal parts for aircraft and missiles. Since there are now about 80 numerically controlled machine tools in the space/aero industry (out of 105 ordered by the USAF in 1954 at a cost of $50 million),





for "wet wing" Boeing B-52G bomber, mine door for Martin SeaMaster, and selected small parts made at Convair-Ft. Worth. About 80 numerically controlled machines are now in use by the space/aero industry.

How APT Program Works

(1) Designer conceives a new part.

(2) Draftsman makes detail drawing of the new part.

(3) Draftsman writes program for machining of part in APT language.

(4) Part program is punched onto cards.

(5) General-purpose computer reads a set of master cards to turn itself into an APT computer.

(6) Part program cards are fed into the APT computer.

(7) APT computer produces punched tape.

(8) Punched tape is fed to production machine to control work.

the MIT-developed system is expected to be widely used. This month it is also to be made available to all firms that either operate or have access to an IBM 704 or 709 computer. These firms need not be members of AIA but must be able to use the APT system for the production of defense material.

A simple code language is used

Key to the APT system is a relatively simple, English-like language by which humans can feed part descriptions and cut sequences directly into the IBM 704 or 709 computer. This language, designed for the convenience of human programers, can readily be translated and understood by the computer.

Its major advantage is that it enables personnel who have no knowledge of computers but have wide tooling and production experience to work with highspeed digital computers. Once the data is fed to the computer on cards, the language starts the computer program so that calculations for cuts are made and the proper information is coded on machine control tape. Electric devices on the numerically controlled tool, set in motion by the tape, guide the cutter motions.

Medium-size computers suited to APT

The APT system has been devised around the IBM 704, but advanced studies are under way to use other computers as well. Scientists believe that medium-size computers and perhaps even smaller models can use the APT system. And while the metals used with numerically controlled machine tools have usually been aluminum alloys of various types, various companies are experimenting with steels and steel alloys at their own expense.

USAF, MIT, and AIA experts are convinced the new APT system, through its standardized language, can be used throughout the industry to reduce production costs by cutting the steps between part design and fabrication. They also feel it is capable of growth so that increasingly complex parts can be produced with less manpower.

The APT system at present has not completely eliminated the need for manual programing. But a year-old test by various AIA member companies and research conducted at the MIT Servomechanisms Lab indicates a "significant portion" of the aircraft, missile and spacecraft parts now being manufactured can be produced by using the APT system in its present state of refinement. MIT and AIA are confident that manual programing can ultimately be completely eliminated.

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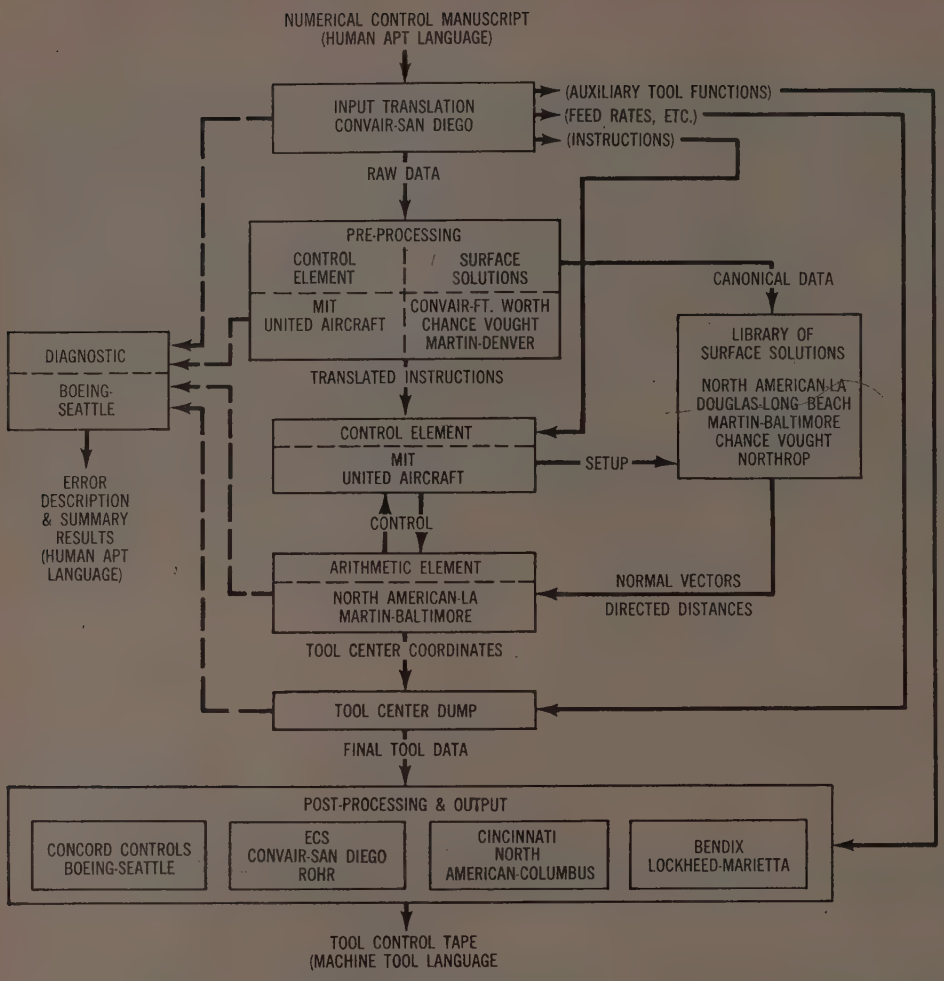


SETUP for further research and development on the APT program. Basic information on APT—in the form of "card decks"—is also held by Bell Aircraft, Goodyear, Grumman, IBM, Lockheed - Burbank, Marquardt, McDonnell, Republic Aviation, Rocketdyne, and Union Carbide.

The industry-wide test began in April 1958, when MIT gave the first field trial package to 19 aircraft plants. The package included 8000 computer cards and 200 pages of preliminary program documentation.

When MIT begins releasing its APT studies to all industry this month, participating firms (starting with the 19 AIA companies) will receive six separate volumes containing more than 600 pages of text and illustrations. Subsequent revisions will be made available at a nominal charge from AIA's Technical Service office in Los Angeles.

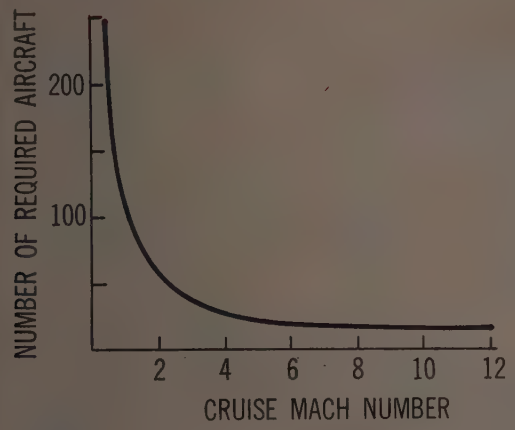
First standard programing system

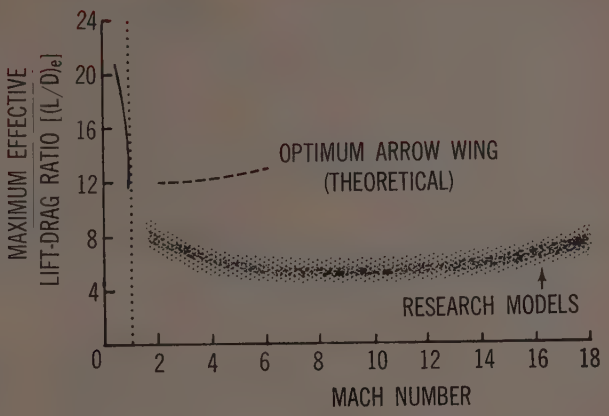
The APT system is not the first automatic programing system ever devised. Several interim systems are already in operation, but they have only limited application. MIT scientists point out that APT is the first standardized system that can be used by any company with a large computer and also the first to meet the long range requirements of advanced numerically controlled production.

With transfer of program coordination from MIT to the AIA Technical Service's APT Project Coordinating Group, MIT is planning additional research to make the system handle even more complicated parts and eliminate manual programing completely. The projected AIA program, which provides for participation by qualified non-AIA companies, calls for a two-year effort to accomplish specified refinements. But this interval will be cut substantially if qualified segments of national industry take part, AIA Technical Service officials believe.

APT may solve lead time problems

To the technical manager for whom the need for compressed lead time is one of his major headaches, the APT system promises a major breakthrough. To the production executive, it foreshadows the output of flawless aircraft and missile parts. To the Air Force procurement official, APT shows signs of slowing down the rise in costs—even though parts and components continue to get more complex.—End





FIGURES 1 & 2: NASA curves (left) shows airline fleets would shrink with increasing speeds. They assume (1) yearly volume of three billion ton-miles; (2) 36,000 lb payload; and (3) eight hours' daily utilization per plane; average speed including (4) 1¼-hr allowance for taxiing, takeoff, approach, and launching and (5) acceleration limited to 0.2G and deceleration determined according to aerodynamic drag. Right: Speed vs maximum effective lift-drag ratio. Model values were obtained in NASA tests; dashed curve is for planar all-wing configuration.

Mach 3-5 airliners

look economically feasible

In theory, supersonic airliners would follow logically from today's subsonic jet transports and high Mach bombers. In practice, designers seem to have quite a few doubts about their overall feasibility. Here is a detailed analysis of this crucial and tricky problem, based on our present knowledge and the advances in the state of the art that can reasonably be expected.

by J. L. Jones and D. H. Dennis

Chief, 8x7-ft Wind Tunnel Branch, & Aeronautical Research Scientist, resp., Ames Research Center, National Aeronautics & Space Administration[1]

SUPER- OR HYPERSONIC transport aircraft obviously would be best suited to the intercontinental and long range domestic routes. In discussing their feasibility, let us assume an ultimate, or zero-reserve, range of 5000 statute miles as the best basis. In 1957, the total long-haul traffic of U. S. airlines on both domestic and intercontinental routes was one billion ton-miles, so we'll assume a figure of three billion ton-miles for the time when super- or hypersonic transports might be in service.

Figure 1 shows, as a function of cruise speed, the number of aircraft that could provide this traffic capability with 36,000-lb payloads and a utilization of eight hours per day. Variations in traffic, payload, or utilization would affect the absolute number of planes required at a given speed, but wouldn't change the relative requirements.

We can see that fewer aircraft are needed at supersonic speeds. However, each plane will undoubtedly

(1) Ames Research Center, National Aeronautics & Space Administration, Moffett Field, Calif.

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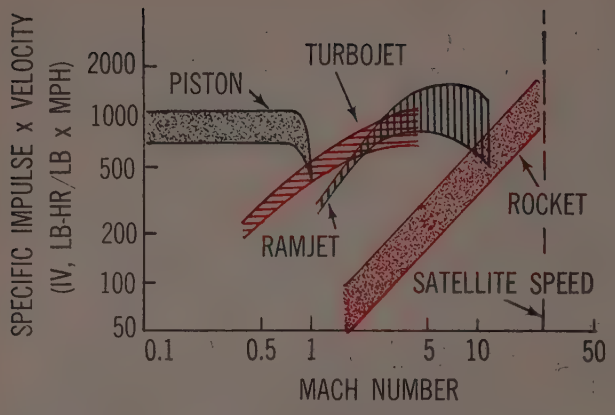
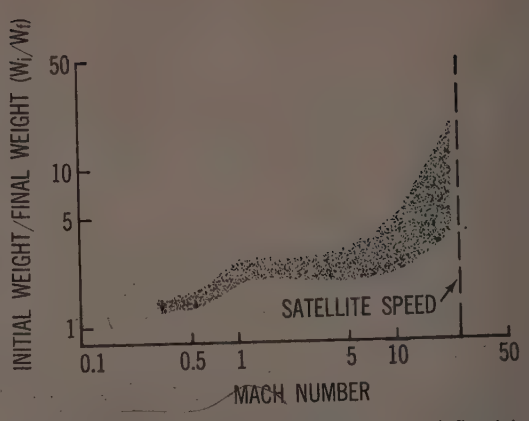




FIGURES 3 & 4: IV parameters (left) for various types of engines. Right: W_i/W_f for 5000 miles ultimate range. Performance calculation for boost-glide and ballistic vehicles used effective L/D and effective IV as defined by Eggers, Allen, and Neice of NASA to permit application of Breguet range equation for these craft.

cost more to buy and operate. To estimate relative costs, we must know something of the size of a plane and its fuel needs. For the latter, the Breguet range equation may be used:

$$range = IV(L/D)_e \log_e W_{i(initial)}/W_{f(final)},$$

where $(L/D)_e$ equals $(L/D)/[1 - (V^2/V_e^2)]$.

For the most efficient performance, or the greatest range with a given ratio of W_f to W_i, both IV and $(L/D)_e$ should be as large as possible. $(L/D)_e$ contains a term to account for centrifugal force in a curved flight path around the earth. This force is opposed to the gravitational pull on the plane and reduces the aerodynamic lift needed to sustain the plane's weight. The effect is noticeable at Mach 5, at which a 3½ per cent increase in $(L/D)_e$ is obtained (and grows in importance until, at satellite speed, no aerodynamic lift at all is needed).

Figure 2 shows the effect of Mach number on maximum obtainable $(L/D)_e$. The increase in $(L/D)_e$ at higher speed is due to centrifugal force. The maximum L/D values for research configurations, which were obtained in wind tunnel tests, in many cases apply to idealized designs. Adding such components as stabilizing fins, pilot's canopy, etc., also would reduce the measured values below the range shown in *Figure 2*. The value of turbulent skin friction, though, would be reduced in extrapolating these data to full scale flight, and this generally would have a compensating effect.

L/D_{max} varies little above Mach 1.5

Higher maximum L/D values are theoretically possible, as is also shown in *Figure 2*, but they haven't been realized as yet in tests. Of greatest importance in *Figure 2*, though, is the relatively small variation in maximum values for L/D beyond about Mach 1.5, as compared with the large reduction through the transonic speed range.

The IV term of our form of the Breguet range equation is, of course, affected by the type of propulsion system that is used. *Figure 3* plots this factor as a function of flight Mach number.[2]

(2) The comparison is an extension of that presented in H. Julian Allen, "Hypersonic Flight and the Re-entry Problem"; *Jour. Aero. Sci.*, 25/4 (Apr. '58).

To realize the maximum values of *Figure 3* for ramjet, turbojet, and rocket engines will require great advances over present systems. Also, if any of the high energy fuels can be used in transport powerplants, specific impulse (I) might increase further.

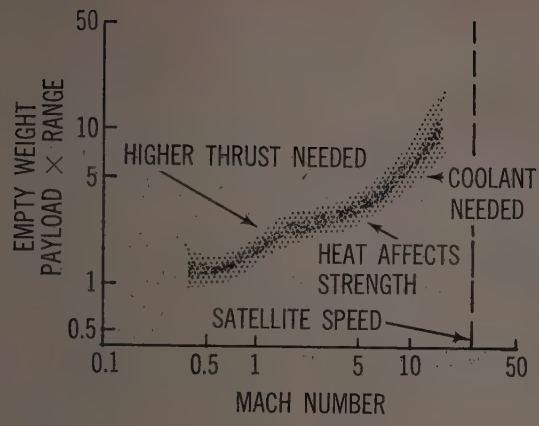
Obviously, different types of propulsion systems are desirable in different speed ranges. Penalties for off-design performance would be greater for the higher speed aircraft using ramjets, and their takeoff and landing performance would require special considerations. Compound systems may have to be developed to permit operation over wider speed ranges. Of primary interest here, though, is the fact that IV values at least as high as those for subsonic speeds may be realized at nearly all supersonic speeds.

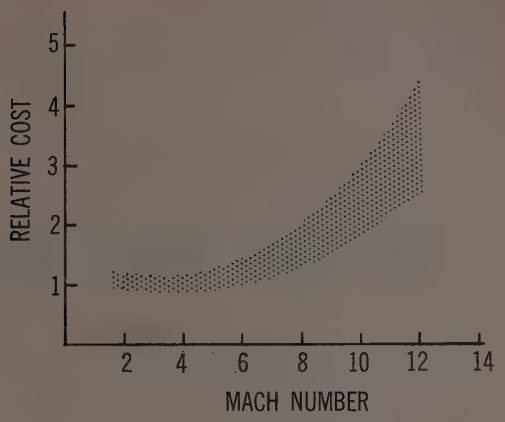
With average L/D values and the IV ranges of *Figure 3*, the variation with Mach number of W_i/W_f for a range of 5000 miles has been computed (*Fig. 4*). W_i/W_f indicates the efficiency in transporting a given load over the specified range—we can see, for instance, that, if the upper W_i/W_f value of about 2.7 is used for Mach 1.5-5, 1700 lb of fuel is needed for every 1000 lb of final, or landing, weight. This is of little significance, however, unless we know the empty weight.

Without detailed designs, these weights are very hard to predict accurately. It's possible, though, to indicate trends in empty weight by considering the main factors that are expected to affect this parameter (*Fig. 5*).

At speeds up to those of current jet transports, the weights of planes capable of performing a 5000-mile mission show little effect of design speed. This parameter would be expected to increase markedly through the transonic speed range, because the higher drag at these speeds would require greater thrust and so increase airframe and engine weight. At low supersonic speeds—up to about Mach 3—only slight additional increases would be expected.

Of course, with increasing speed, aluminum will become inadequate for many structural members. There's some question as to whether the use of heavier but stronger materials will significantly increase airframe weight. Beyond Mach 3, the effects of aerodynamic heating will probably cause increases in structural weight. The weight of the cabin cooling system would

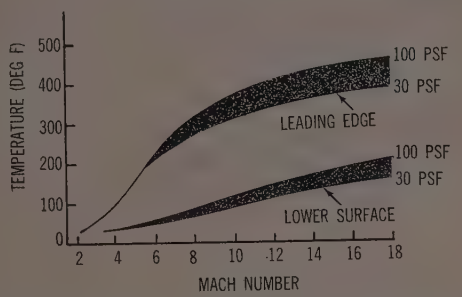




FIGURES 5 & 6: Expected trends (left) in transport design (based on 5000 miles ultimate range). At low supersonic speeds—up to about Mach 3—only slight additional increases are expected in the effect of design speed. Right: NASA estimates of relative yearly fleet costs for supersonic transports.

also be expected to go up markedly. As flight speeds increase further, critical areas, such as leading edges, will attain temperatures high enough to require cooling equipment, which will add still more weight.

On the basis of these trends, we can estimate the relative annual costs of fleets designed to cruise at various Mach numbers (*Fig. 6*), if we assume (1) the relative number of planes in *Figure 1;* (2) relative initial costs based on $40 per pound of empty weight for all speeds and on the empty weights obtainable from *Figure 5* for a payload of 36,000 lb; (3) a uniform amortization period; (4) fuel costs based on *Figures 4 & 5;* (6) airframe and engine maintenance costs scaled in proportion to plane weight; (7) crew and indirect costs that are independent of cruise speed, with the indirect costs for a reference craft giving Mach 0.8 and eight hours daily utilization and computed by the revised 1955 ATA method.



EQUILIBRIUM temperatures as function of speed for an uncooled wing (with a leading edge diameter of three inches) at various loadings show aerodynamic heating problem at high supersonic speeds.

Subsonic jets cheaper than expected

The validity of some of our assumptions can't be verified without much more detailed studies—possibly not even without actual construction and operating experience. This poses an obvious problem, since even slight changes in the values we have assumed could drastically affect our cost figures. The cost per pound, for example, might be much greater than we assumed if the $40 figure were doubled, relative fleet cost per year would increase by about 30 per cent for Mach 3 and by 25 per cent for Mach 5. In this specific instance, though, we can find reassurance in the fact that costs for subsonic jets have turned out to be substantially below the early estimates.

Utilization, of course, affects the relative annual fleet costs greatly. Recent estimates indicate that the utilization of the subsonic jet transports may have to be as high as 10-11 hours per day if these planes are to show a profit. If constant for all Mach numbers, a change in utilization from eight to 10-11 hours would result in only minor changes in our comparison, for its cost figures are relative.

However, the greater number of flights the supersonic plane could make per day would require more turnaround periods. The shorter flight times furthermore, would make scheduling for use of the early morning period more difficult. It may not be possible to keep the utilization of the supersonic jet at the level of its subsonic predecessor. If this proves true and the drop in utilization came to as much as 50 per cent, the relative supersonic fleet costs would be doubled.

We can conclude that there is a good possibility of achieving economical commercial flight at supersonic speeds up to about Mach 5. However, the design of transports for these speeds must follow continued advances in technology and experience with supersonic military aircraft.

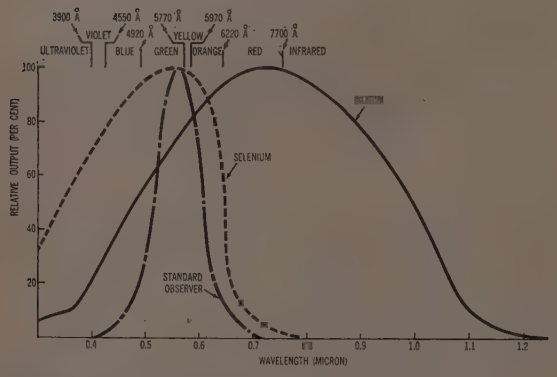
On the other hand, we can also see that, for speeds above roughly Mach 5, relatively small reductions in fleet size can be achieved. We have shown that, as speed goes up, large increases in airplane and fuel weights are to be expected. At over Mach 5, therefore, the long haul missions we have considered can be flown only by aircraft with much higher gross weights—which mean higher costs. Commercial flight at these speeds seems unlikely, unless revolutionary developments in propulsion and structural materials occur.—End

Solar cell R&D

shooting for 16-22 per cent efficiencies

Next target for solar cell engineers is the two-kilowatt power supply that has been proposed for space vehicles. To reach it, higher efficiencies must be achieved in designs based on the present state of the art.

by Joseph I. Davis,
Manager, Missile & Test Equipment
Hoffman Laboratories Div., Hoffman Electronics Corp.*



ENERGY spectrum for selenium and silicon solar cells.

PRACTICAL SOLAR CELL efficiencies run around 10 per cent on a production lot basis. Under lab conditions, this has been boosted to 14 per cent for silicon cells. But this is still short of the theoretical maximum, estimated at 16-22 per cent.

Many variables affect solar cell efficiency. Most important are the physical properties of the cell. Silicon, in its ultra-pure state, is actually an insulator. It takes the addition of a microscopic quantity of impurity (one part per billion or per hundred million), or "doping", to make the cell work.

Doping turns the silicon into something between a conductor and an insulator. The disordered crystal lattice structure that results is what permits the conversion of light energy into electricity.

Doping silicon, which has a valence of four, with a five-valence element such as arsenic or antimony results in a surplus of one electron in any finite junction of the silicon and contaminating element. This is called an N-type material, because there is a surplus of electrons free to move about.

A three-valence doping element, such as boron or indium, produces a shortage of one electron in the crystalline structure union of the two elements. Because there is a "hole", or deficiency of electrons, we speak of P-type material.

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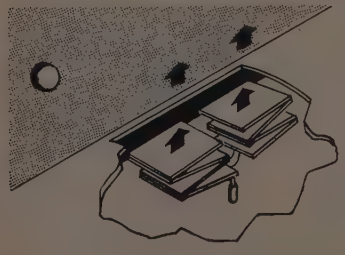
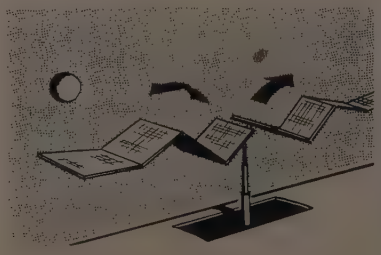
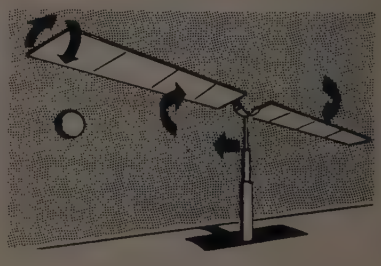
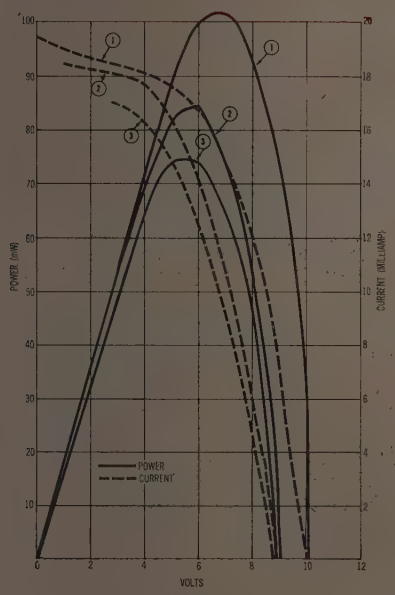
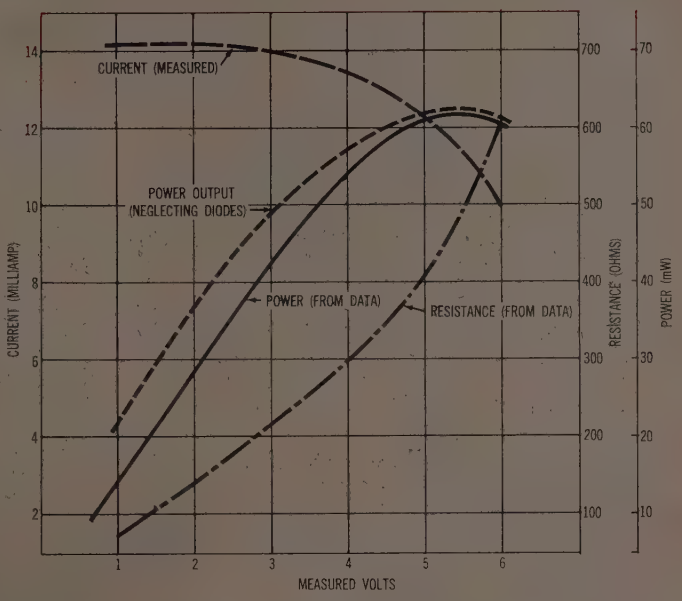
COMPACT DESIGNS have been proposed for oriented solar cell power supplies that, based on state of the art, could produce two-kilowatt power. Parabolic collection (left) effectively increases the intensity of the incident











POWER OUTPUT and current flow of the Vanguard cell block (left) made up of 18 cells in series. At the time of test, the weather was fair with slight high altitude cloudiness. Run 1 was made without diodes or window, run 2 with diodes and without window, and run 3 with diodes and window. The air temperature in the shade was 61 deg F, the case temperature was 92 deg F, and the cell temperature was 102 deg F. Right: Measured and calculated test data summarizing the performance of the Vanguard cell block.

Pieces of N-type and P-type material can be brought together to form a perfect single crystal. Apart, both pieces are neutral, with the charge of ionized impurities exactly equal to the charge of the current carriers. Upon joining, there is an excess of electrons on one side of the junction, matched by an excess of holes on the opposite side.

This results in a net transfer of charge that makes the P-region negative with respect to the N-region and sets up an electric field in the direction opposed to the flow due to diffusion of electrons. Under thermal equilibrium conditions, there is no current flow. Electrons are kept in the N-region and holes are kept in the P-region, but there does exist a potential gradient across the junction.

If enough infrared or visible light is concentrated on a P-N junction semiconductor, it will create electron-hole pairs. The pairs that are in or very close to the junction are separated by the static electric field, which pushes the holes into the P-region and the electrons into the N-region. This builds up an external voltage, so that connecting a wire across the two ends of the junction causes current to flow in the wire from the P-side to the N-side.

Silicon solar cells generally consist of a wafer of an N-type material about 0.016 in. thick in which a surface region has been converted to P-type by diffusion of a three-valence material into the crystal. The thickness of the P-layer is kept to around 0.0001 in. to minimize

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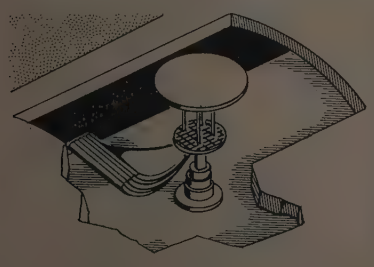
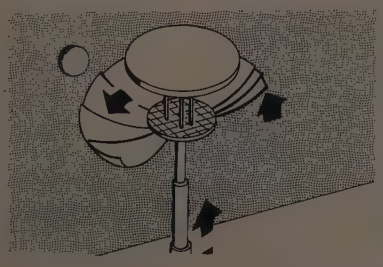
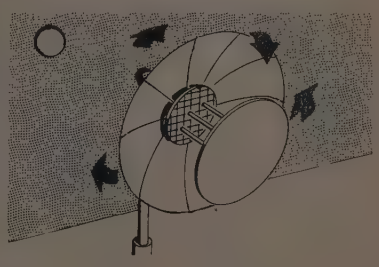
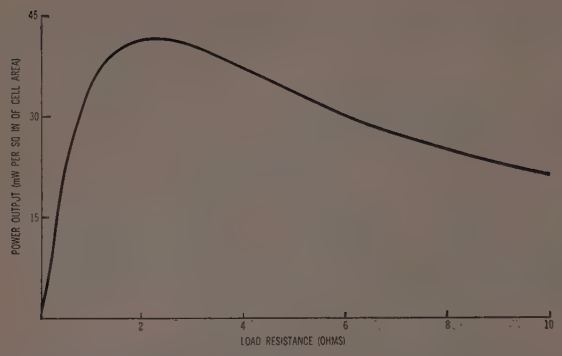
energy which is focused and bounced off a reflector onto the solar cells. Both designs show here can be positioned in three axes to track the sun so the cells are always normal to the incident rays.









TYPICAL POWER OUTPUTS of a silicon solar cell. Curve is for a cell with an effective area of one square inch illuminated by the noonday sun.

the recombination of electron-hole pairs before they reach the junction barrier.

Today's cell sizes are limited by crystal growing techniques to a maximum diameter of about three inches. The only practical way to increase the area now is to solder together several cells.

Several other techniques are being studied. Sintering, for example, has been tried, preceded by cold-pressing of the silicon granules into a compact mass. However, only 90 per cent of the normal silicon density has been achieved. (Tests with hot pressing prior to sintering are also being made.) One of the problems that remains to be solved is to reduce the effect of multiple grain boundaries formed in sintered cells.

Another technique—studied briefly but dropped because it seemed too difficult—is to make a composite cell of many tiny granules of silicon all having separate P-N junctions. The problem here is to connect the P- and N-regions of all granules while preserving a well-cleaned and isolated junction surface. Orientation effects are expected to be small.

Preliminary tests have also been made of casting sheets of silicon. Through a process of vacuum melting and solidification, it proved possible to fabricate crystals up to 1/16 in. in diameter without special cooling.

More promising studies have been devoted to large solar converters made from evaporated silicon films. Layers up to several microns in thickness have been successfully deposited by evaporation onto various substrata.

No permanent substratum known yet

Problems still to be solved are the deposition of films with only a few grain boundaries and the formation of P-N junctions. At present, no substratum is known that is physically as well as economically satisfactory as a permanent material, so that films still have to be separated from the substratum. The size of silicon layers formed by this method is limited to the size of the substratum crystal. P-N junctions can be formed either by doping during evaporation, by alloying to the contact layer, or by diffusion.

Another answer would be to develop new semiconductor materials. However, silicon still seems to be the most practical production material we have right now.

For space vehicle applications of silicon solar cells, it is important that the following factors be considered very carefully:

- *Mechanical Mounting*—The cells must meet the full shock, vibration, and acceleration requirements of the boost phase of initial flight. Acoustic damage and mechanical resonances must be thoroughly investigated to insure reliable mechanical operation.
- *Heat Transfer*—Thermal analyses show that solar cells oriented in space without any special heat dissipating provisions would be rendered useless by the heat that is generated. This means the cells must be mounted on a suitable heat sink or the backs of the cells must be coated with a high-emissivity compound so the cells can radiate thermal power to outer space.
- *Protective Coverings*—There is some question today whether the amount of micrometeorite erosion of solar cells is worth the weight penalty or expense of covers. It is planned that a future space vehicle carry both plastic and fused-silica coverings to help answer this question.

Optical coatings are also being studied to determine the effectiveness of rejecting the unwanted portion of the solar spectrum that cannot be converted to electric energy and only raises the cell temperature. Silicon monoxide is among these coatings. A good optical filter, coated onto silicon solar cells and backed up by an effective emissive compound, could lead to extremely cool operation and boost cell efficiencies.

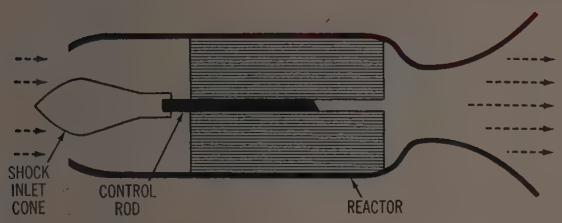
- *Uniform Lighting*—The amount of energy impinging on any surface is a function of the normal incidence of light. This varies as the cosine function of the normal incidence, so that it is extremely important that the solar cell power supplies be arranged to take advantage of optimum lighting conditions.

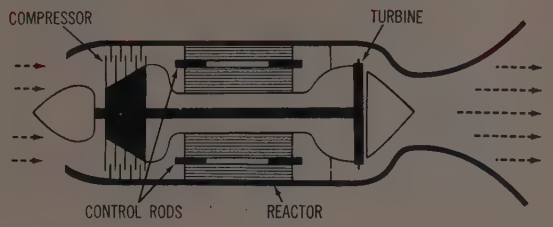
Oriented system uses fewer cells

This can be done by using oriented solar panels or by going to a spherical solar array, which presents a constant surface area to the sun. An oriented system is preferable, for it uses fewer solar cells. However, it adds complexity and weight.

The advantage of an unoriented system is its simplicity. About four times as many solar cells are needed, though, as in an oriented system, and the lighting must be uniform, since the array is made up of many series of parallel-connected solar cell strings. A solar cell characteristically has a relatively high electric impedance when not illuminated. Should a portion of the series not be lit, the output voltage from that series string drops markedly.

- *Circulating Currents*—Most solar power supplies are made up of many series-parallel strings of solar cells. Since the characteristics of each series string normally are slightly different, protective diodes must be inserted in each series string to minimize circulating currents between series-parallel strings. The diodes also act as safety devices in the event a series string shorts out. The characteristics of the diode should be such that it could handle large amounts of peak current and provide a low series voltage drop.
- *Radiation Damage*—Preliminary findings on the effects of radiation on solar cells indicate that electric characteristics deteriorate upon exposure—but to what extent has not yet been determined. Radiation damage, of course, is characteristic of all semiconductor devices, and it is clear in any case that solar power supplies should be derated if radiation is expected.—End





ATOMIC ramjet engine (left) as conceived by Soviet designers. Right: Calculated weight of this atomic turbojet engine, including the reactor and its reflector, is 15 tons. It has a length of 6.5 m and a diameter of 2.3 m. Sea level thrust is 32 tons. Assuming an aircraft with a flying weight of 130 tons were to be equipped with two of these engines, it would have a maximum speed of 2100 km/hr at 11,000 m altitude.

First airborne atomic engines will be

nuclear-chemical hybrids

This is the third and last article in a series based on a detailed, authoritative Soviet engineering report on airborne nuclear engines. The first two articles of this series, dealing with general design features and control problems, appeared in January (p. 132) and February (p. 43) of this year.

by G. N. Nesterenko, A. I. Sobolev and Yu. N. Sushkov*

AN ATOMIC RAMJET is the simplest type of nuclear powerplant. It amounts to a "flying reactor" with a diffuser in the nose and a jet nozzle in the rear. Even the shock inlet cone can double as a housing for the reactor control rod servo drives.

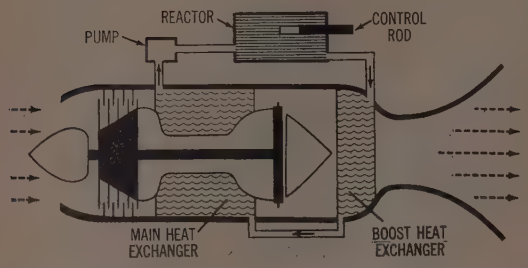
True, atomic ramjets have a lower specific thrust than conventional ramjets, mainly because of their air temperature limit. The structural materials of modern reactors can only take up to 1000-1100 deg C, whereas, in the ramjets flying today, combustion temperatures can easily go to 1500 deg C. However, thrust can be boosted by increasing the dimensions of the atomic ramjet so that it handles a greater volume of air.

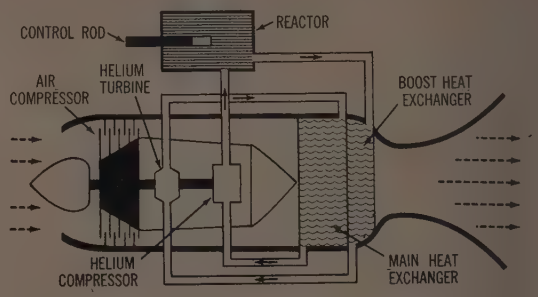
The maximum cross-section of such a ramjet will correspond to that of either the diffuser or the reactor, depending on speed. Calculations show that at Mach 2.5 or less, the reactor will invariably be larger in diameter than the diffuser. The only way to increase frontal thrust here is to reduce the reactor cross-section.

Such considerations naturally lead to the idea of a remote, or "buried," reactor system. Ram air, entering the engine diffuser section, can be heated by an intermediate heat transfer agent circulated between engine and reactor. Since the coefficient of heat transfer from

more on next page

*Condensed from "Primeneniye Atomnykh Dvigateley v Aviatsii" (Application of Atomic Engines in Aviation), Military Press of USSR Defense Ministry, Moscow '57, a partial translation of which is available as "PB-131908T" at $3 from Dept. of Commerce, Office of Technical Services, Washington 25, D.C.





ATOMIC engine (left) has supplementary heat input. Intermediate heat transfer agent carries heat from reactor to air flow. Center: Atomic turbojet with helium-driven air compressor and supplementary heating. Two uranium-beryllium engines of this design (using intermediate neutrons) could each deliver 20 tons sea level thrust while sharing a single reactor. Helium pressure is 25 atm at compressor input and about 52 atm at reactor input. Compression ratio of air compressor at 5850 rpm is 2.3. Total of 370 kg/sec of air passes

the reactor surfaces to the heat transfer agent is many times larger than for air, the reactor can be made a good deal smaller.

The advantages of this approach are balanced by the fact that the design is more complex and engine response is slower. The thrust of an atomic ramjet in which the air is directly heated in the reactor begins to increase at the instant the control rod is pulled out. With an intermediate heat transfer agent, thrust begins to increase only after the transfer medium has been heated.

Ramjet still limited in operation

A basic drawback of any ramjet is its inability to produce thrust on the ground and at low flight speeds. It must be used with other engines to get up to operating speeds.

The atomic turbojet, of course, can be used for an entire mission. It may be objected that in such a turbojet the air becomes radioactive and so a safety hazard. However, careful study shows this is not so.

Argon—which is present in less than one part in 100—contains the bulk of the radioactive radiation in the air. Radioactivity may also be produced by an isotope of oxygen, by water vapor in the air, and by dust. But the air passing through the engine constantly mixes with the ambient atmospheric air, so that the concentration of radioactivity drops rapidly.

Radioactivity drops off very quickly

Actually, the radioactive zone behind an atomic turbojet is no more dangerous than the flame of a conventional jet. At the point at which the temperature from the jet exhaust has dropped off enough so that anyone entering the air stream does not suffer a burn, the radioactivity has also dropped off enough so that it no longer endangers the human organism.

Radioactive dust is another matter. Any dust settling on the airfield is likely to have a high radiation level of rather long duration. This threat can be counteracted by laying concrete runways, wetting the runway with water before takeoffs, installing suction vents to continuously remove dust, and similar measures.

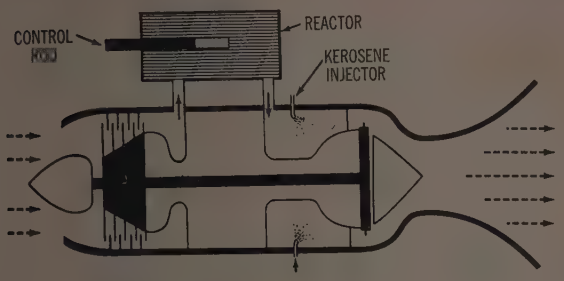
Of the many possible atomic turbojet designs, the simplest differs from the conventional jet only in that the combustion chamber is replaced by a reactor. In the early phases of atomic engine development, many engineers believed the compression ratio of an atomic turbojet would have to be considerably greater than that of a conventional one. It was held that the compression of the air even at high flight speeds would be insufficient to drive the air through the ducts of the reactor. Later it was found that the optimum compression ratio of an atomic turbojet's compressor, calculated to yield a maximum frontal thrust, is unexpectedly close to that for a conventional turbojet.

Multi-stage cooling in compressor

Increasing the compression ratio makes it easier to dissipate the reactor heat. However, at high flight speeds the total compression (due to velocity head and compressor) rises excessively. The temperature of the air past the compressor increases so much that the reactor can impart very little heat to the air. The end result is that the thrust falls off.

One way around this problem is to use a multi-stage compressor with cooling after each stage. If the air inlet and outlet are properly laid out, the heat exchanger between the compressor stages functions basically as a ramjet and adds to the overall thrust.

Though the atomic turbojet is simple in principle, its practical design is made very difficult by almost insurmountable shaft cooling problems. The shaft connecting the turbine with the compressor has to pass through the reactor. It absorbs quite a bit of heat from the hot reactor parts, but even more important



through heat exchanger of each engine at sea level. The 48,500-hp helium turbine needed to drive the air compressor is powered by a six-stage axial helium compressor rated at 94,800 hp at 16,000 rpm. Right: Turbojet using nuclear and chemical fuels.

is the fact that the shaft material itself generates heat due to the scattering and absorption of neutrons and gamma rays.

This problem could be overcome by installing the reactor outside the engine. Then the air can be bypassed from the diffuser to the reactor and be ducted back into the engine for exhaust into the atmosphere.

Inevitable heat losses through the duct walls, as well as fluid flow friction losses, tend to reduce the cycle efficiency. But the reactor is far removed from the engine, so that radiation shielding becomes a good deal simpler.

Reheating much as in afterburner

Thrust can also be boosted by reheating the air after it has passed through the turbine—much as in an afterburner, only with the supplementary heat provided by means of an intermediate heat transfer agent. Instead of going directly to the main heat exchanger (before the turbine), the heat transfer agent moves from the reactor to a heat exchanger behind the turbine. From there, having surrendered part of its heat, it proceeds to the main heat exchanger.

A similar boost in thrust can be produced if an auxiliary engine, not energized by the air heated in the heat exchanger or the reactor, is used for driving the air compressor. A steam or gas turbine using mercury vapor or helium and operating on a closed cycle is well suited to this application.

Pump is needed for mercury turbine

With mercury, a pump is needed to force the liquid mercury under high pressure through the reactor, where it is heated and converted into vapor to drive a mercury turbine coupled to the air compressor. The expended mercury is then condensed and recycled into the reactor.

Any reactor operating on this principle must be a fast-neutron type, since mercury is an avid absorber of thermal neutrons. It may even prove better to heat the mercury in a heat exchanger by means of an intermediate heat transfer agent rather than directly. Then the neutron absorption will not fluctuate too much with the density change involved in the conversion from a liquid to a vapor.

Helium turbine requires more power

If a helium turbine is used, its power must be several times higher than that of a mercury turbine to supply the same power to an air compressor. Far more power—several tens of times greater than that going into a mercury pump—is needed to drive a helium compressor. For example, more than 100,000 hp of a 150,000-hp helium turbine is consumed in rotating the helium compressor. What is left—less than 50,000 hp—is all that can go to the air compressor.

A mercury turbine to provide the same power for an air compressor would need only 53-54,000 hp. However, the reactor power in either case is about the same, since the efficiency of the helium turbine under comparable operating conditions is considerably higher.

Using helium as the working medium and heat transfer agent raises the operating temperature range of the reactor. With special chrome-nickel alloys as the structural material, the heating surface of the reactor could go to 1000-1100 deg C. Beyond that, the mechanical strength of these alloys falls off.

Oxidation is problem with molybdenum

Temperatures could be raised by another 200-300 deg C if molybdenum alloys were used. The hitch is that this metal has a high oxidation rate and cannot be allowed to come into contact with air. So long as molybdenum can be surrounded by helium or other inert gases, though, it will retain its mechanical strength for a long time at very high temperatures.

It looks as though, for the immediate future, the most practical engine designs will combine the use of nuclear and chemical energy in a single powerplant, with the reactor housed separately from the engine. Air is first heated by the reactor and then ducted to the combustor section. Kerosene is injected into the heated air to further increase the air flow temperature.

Were the turbine to use cooled blades, the temperature of the air could be raised to 1500 deg C. If the design is limited to standard temperatures ahead of the turbine (on the order of 800 deg C), the temperatures would have to be controlled to approximate those in a regular atomic turbojet.

Limited range with hybrid system

Most likely, airborne combination systems will be developed before a purely atomic system. It is quite doubtful, though, whether the range of flight with such a combination engine will exceed that of aircraft with conventional engines.

It is quite probable that atomic jet engines with kerosene afterburners will be used. These engines will have a standard afterburner chamber between turbine and jet nozzle in which the air will undergo supplementary heating. The afterburner will be turned on for brief periods for takeoff, climb acceleration, and flight at maximum speed.—End

Variable-speed, synchronous-flux generator delivers 20-120 kva

Here is a report on a successfully demonstrated variable-speed, synchronous-flux system using a semiconductor frequency changer. The system is claimed to have about the same size and weight as comparably rated synchronous generating systems but to be superior because it gets along without a constant-speed drive.

by Victor DeBiasi, Associate Editor

FOR YEARS, aircraft electrical engineers have been hoping to make the constant-speed drive obsolete. Their goal—efficient generation of constant-frequency electric power directly from a variable-speed engine or input drive shaft.

Most constant-frequency generating systems for aircraft are designed around a hydromechanical constant-speed drive (CSD) and a synchronous generator. The CSD converts the variable speed of the input shaft into a constant speed—usually 6000 rpm—to drive the generator. All frequency control is exercised through speed regulation.

Several months ago, Jack & Heintz, Inc., 17600 Broadway Ave., Cleveland 1, Ohio, demonstrated a lab prototype of an "electrically synchronized" 400-cycle generating system based on a feasibility model built in early 1958. Major features of the system were:

- 3000-9000 rpm input speed range (with a 12,000-rpm capability),
- 0.06 seconds voltage recovery from full load to no load,
- ± 1 per cent steady-state voltage regulation,
- frequency regulation of five parts in one million.

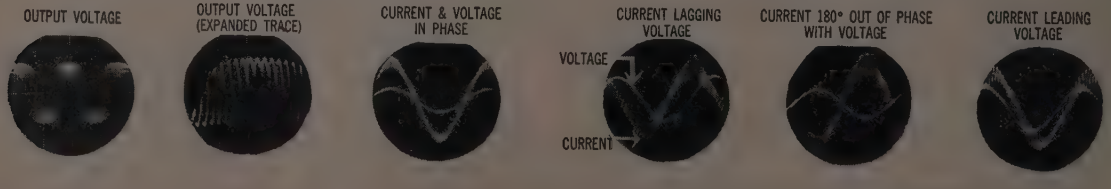
J&H believes it should be able to replace most CSD generating systems with its variable-speed, constant-frequency (VSCF) system. Give or take a few pounds (depending on the application), the competing systems are about the same weight and size, J&H says. Bob Lusk, senior applications engineer on the project, claims the VSCF synchronous-flux generator will actually be a bit shorter than comparably rated synchronous generator CSD combinations.

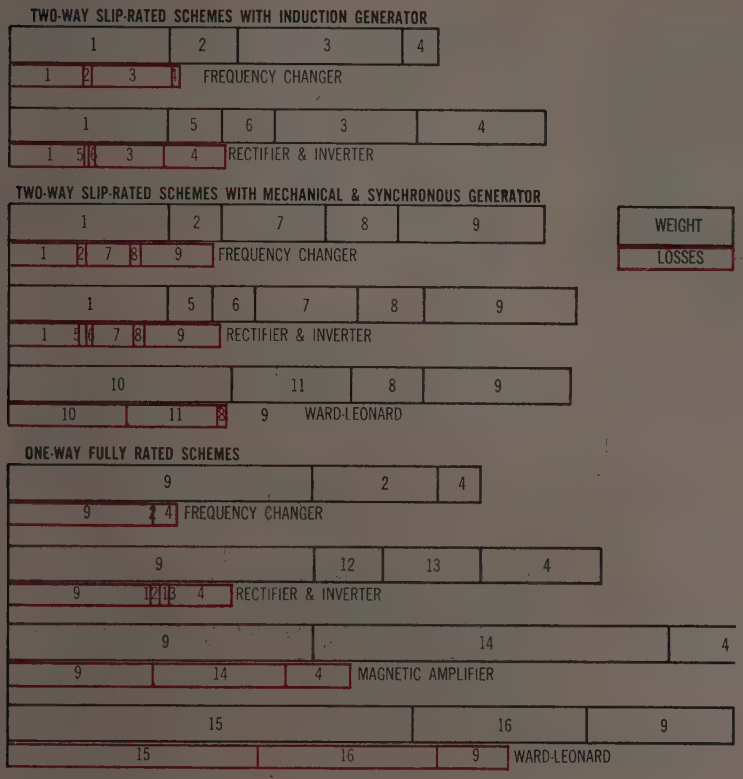
Since weight and size are so evenly matched, it would seem the VSCF system has little to offer. That is so, says J&H—except for reliability and maintenance, which it claims are exceptional and the prime reasons for developing the system.

The argument is that no matter how reliable a CSD may be, it is still a mechanical assembly of precision-fit rotating and sliding parts susceptible to failure. On the other hand, in the VSCF synchronous-flux system, in which the CSD is eliminated, only bearings can present mechanical wear problems. The complexity of the main rotating machine is said to be only slightly greater than that of a rotating, rectifier-type, brushless, synchronous generator.

R&D engineers Keith Chirgwin and Jack Stratton are credited with having contributed most to the develop-

TYPICAL test oscillograms. The first six (left) show the operation of the semiconductor frequency changer feeding into (or out of) the three-phase, 60-cps power supply. The next three show the terminal voltage of the syn-





MOST PRACTICAL schemes for generating constant-frequency electric power from a variable-speed shaft over a range of 3000-9000 rpm. J&H comparison of weights and losses is based on analysis of power handling equipment only, since this makes up most of overall weight and accounts for losses. Components shown: (1) synchronous generator or motor, (2) frequency changer, (3) induction generator, (4) synchronous condenser, (5) rectifier or inverter, (6) inverter or rectifier, (7) synchronous motor or generator, (8) mechanical differential, (9) synchronous generator, (10) dc generator or motor, (11) dc motor or generator, (12) rectifier, (13) inverter, (14) magnetic amplifier demodulator, (15) dc generator, (16) dc motor.

ment of the VSCF system. They built the first lab prototype system early in 1958 to prove the feasibility of their basic design approach. A second, refined version was then demonstrated in October 1958. System performance was just as predicted (once all the bugs were ironed out).

System specially demonstrated for S/A

In a special demonstration for SPACE/AERONAUTICS, Chirgwin and Stratton put this Phase II system through its paces. From the aircraft engineer's point of view, the most important results observed were:

- System output held to a constant 400 cps reading as the input speed was varied—first slowly and then abruptly—from 4000 to 8000 rpm in both directions (with no disturbance in passing through the synchronous speed of 6000 rpm).
- The system could deliver 60 kva at 400 cps into either resistive or inductive loads (with the power factor zero lagging or higher).

The basic elements of the VSCF system are a synchronous-flux generator, a salient-pole exciter, a semiconductor frequency changer, a voltage and frequency regulator, and a voltage balancer. In effect, when the input speed is less than the synchronous speed of 6000 rpm, the exciter feeds power to the generator rotor.

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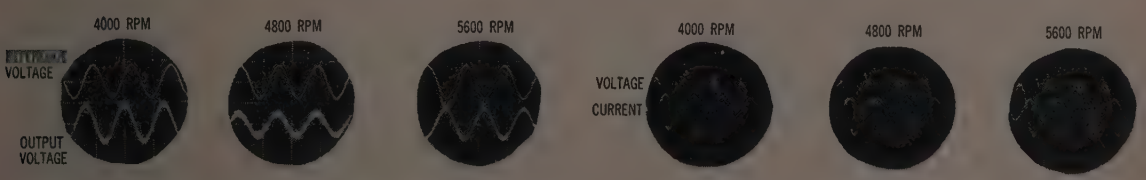
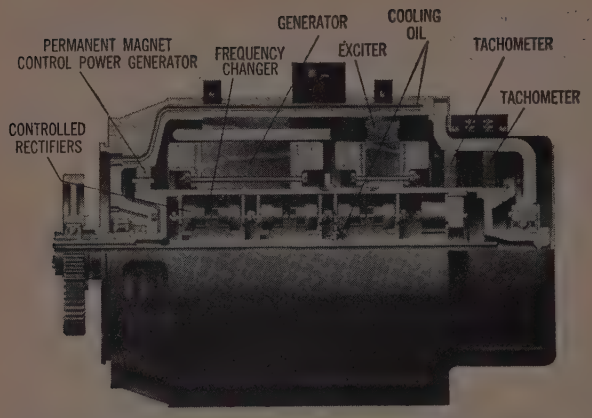
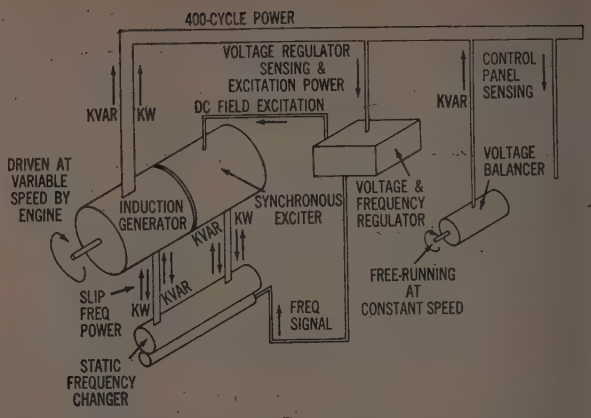


chronous-flux generator feeding a resistive load, with the system's synchronous condenser disconnected. The last three show the complete system (including synchronous condenser) feeding a resistive-inductive load.





JACK & HEINTZ variable-speed, synchronous-flux generator (far left). Company expects it to prove as reliable as brushless, oil-cooled synchronous types in service today. Center left: Variable-speed, constant-frequency lab test system demonstrated in breadboard form for SPACE/AERONAUTICS. It generated a constant 400-cps frequency over an input range of 4000-8000 rpm with no disturbance in passing through the synchronous speed

When the input speed is over 6000 rpm, the power is returned from the generator to the exciter, which then operates as a motor. Actually, the generator field flux is electrically rotated relative to the input shaft to maintain the flux at synchronous speed regardless of shaft speed variations.

The salient-pole exciter supplies both the real and the reactive power needed to excite the rotor windings of the main generator. Its output frequency varies directly with shaft speed.

The variable-frequency output of this exciter is fed to the frequency changer, which converts it into a "slip frequency". In turn, the slip frequency is fed to the rotor windings of the synchronous-flux generator.

The flow of the three-phase, ac slip frequency currents electrically rotates the generator's exciting field. It causes the flux to rotate faster or slower than the shaft speed (depending on whether you have an underspeed or overspeed condition) to maintain a synchronous field flux speed.

The voltage and frequency regulator keeps the system within performance specs. It also provides dc excitation power to the salient-pole exciter and the voltage balancer.

The voltage balancer helps the system meet the unbalanced-load requirements of Mil-G-6099. It is a free-running synchronous machine and so is able to supply some reactive kva.

Under normal load and some fault conditions, the voltage balancer can be used to reduce the demands on the main generator. It also is part of the filter system that eliminates the ripple in the 400-cps output voltage.

Major Component Weights

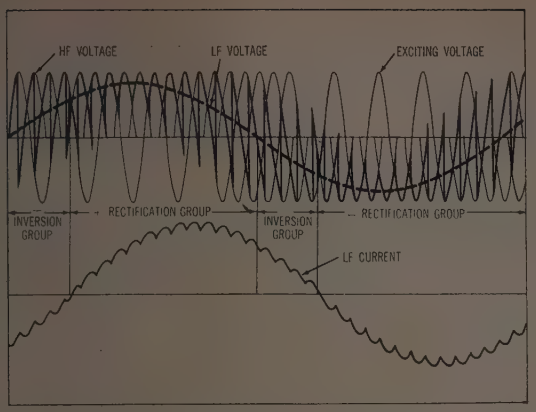
Synchronous-Flux Generator			
Synchronous RPM	30 KVA	60 KVA	90 KVA
6000	65 lb	95 lb	125 lb
8000	60 lb	85 lb	105 lb

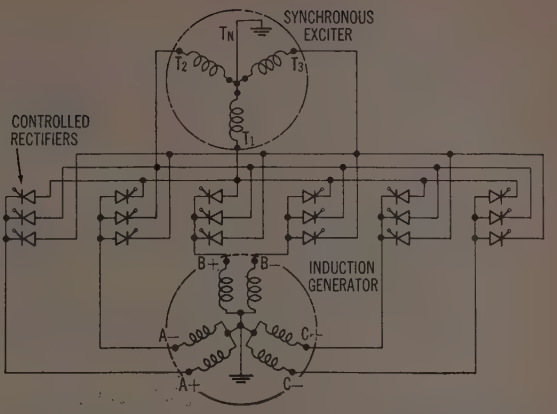
Salient-Pole Exciter					
Minimum RPM	10 KVA	15 KVA	20 KVA	30 KVA	40 KVA
3000	52 lb	66 lb	78 lb	96 lb	116 lb
4000	44 lb	56 lb	66 lb	83 lb	96 lb
5000	39 lb	49 lb	58 lb	73 lb	86 lb
6000	36 lb	44 lb	52 lb	66 lb	78 lb
7000	33 lb	40 lb	48 lb	60 lb	70 lb

Semiconductor Frequency Changer					
Rating (kva)	10	15	20	30	40
Weight (lb)	15	20	25	35	45

Voltage Balancer		
30	60	90
23	33	40

Voltage & Frequency Regulator		
30	60	90
13	17	20





from either direction. Heart of the system is the semiconductor frequency changer. Center right: Three-phase, half-wave frequency changer with 0.7 power factor. For LF voltage, reactance absorbs voltage difference between dashed and jagged waves. Far right: Basic frequency changer consists of six groups of three-phase, half-wave circuits. Half are "positive" and half "negative" for flow of real or reactive power in either direction.

The most important part of the VSCF system—the element that makes the system at all practical for airborne applications — is the semiconductor frequency changer, which handles real and reactive power flow in either direction. It consists of a number of switches (silicon-controlled rectifiers) that are opened and closed to "sample" segments of the variable-speed shaft frequency waves. This on-and-off switching produces a jagged slip frequency wave that is smoothed out by chokes in the circuit before being fed to the synchronous-flux generator.

A silicon-controlled rectifier is used as the switching element. It conducts, or is "switched on", by a small pulse of current applied to the "gate". It stops conducting, or is "switched off", when the anode-to-cathode current is forced to zero by other circuit components. In effect, the controlled rectifier is a solid-state equivalent of a thyratron.

The basic design concepts for each of the three major assemblies in the VSCF system—generator, voltage balancer, and regulator—have been completed. The main unit is the generator package, which includes the main synchronous-flux generator, the salient-pole exciter, an optional PM generator (for start-up and system control power), two signal tachometers, and the semiconductor frequency changer. The package bolts directly onto the engine pad in the space normally taken up by a CSD and synchronous generator.

Generator rotor is unconventional

The generator stator is quite conventional. The rotor, however, differs from the usual alternator rotor—it has a cylindrical, laminated, and uniformly slotted core that which carries an eight-pole, three-phase winding. The winding leads are carried directly to the frequency changer mounted inside the hollow shaft.

The salient-pole exciter basically is a conventional synchronous generator, with the output winding in the rotor and the field, or exciting, winding in the stator. The exciter's rotor is designed just like the main generator's. The stator is made up of slotted steel laminations wound with an eight-pole, dc field winding and a squirrel-cage-type amortisseur winding. Field power is provided by a static exciter.

The frequency changer consists of 36 controlled rectifiers, all located in the hollow shaft (which is oil-cooled). It transfers power between the rotor windings of the salient-pole exciter and the synchronous-flux generator, and receives its rectifier firing signals from the exciter rotor and the rotor of a reference frequency tachometer.

System weight can be approximated

System weight naturally depends on the design application. However, it is possible to approximate it by analyzing the effect of power and speed requirements on the weights of the major components (see *"Component Weights" Table*):

- the synchronous-flux generator, whose weight depends on its rating and synchronous speed;
- the salient-pole exciter, whose weight is a function of the maximum slip speed (or difference between minimum rated speed and synchronous-flux speed), the system's rated kva, and minimum rated speed;
- the semiconductor frequency changer, whose weight depends largely on the number of controlled rectifiers and the rating (which must be the same as that of the salient-pole exciter);
- the voltage balancer, whose weight is determined by the system rating and voltage imbalance requirements (not all of this weight is parasitic, since the balancer is a continuously running motor and so can be used to perform incidental services, such as acting as a cabin blower);
- the voltage and frequency regulator, whose weight to some extent depends on the system rating.

In addition, J&H advises, 13 lb should be tacked on to account for tachometers and a permanent-magnet control power generator. Write in No. 68 on Reader Service Card for more information.—End

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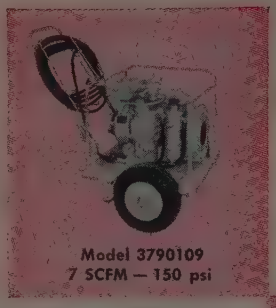

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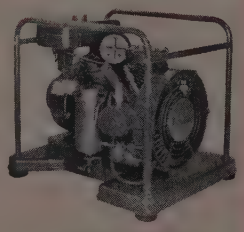

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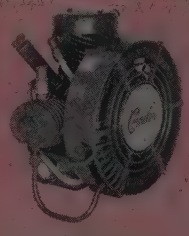

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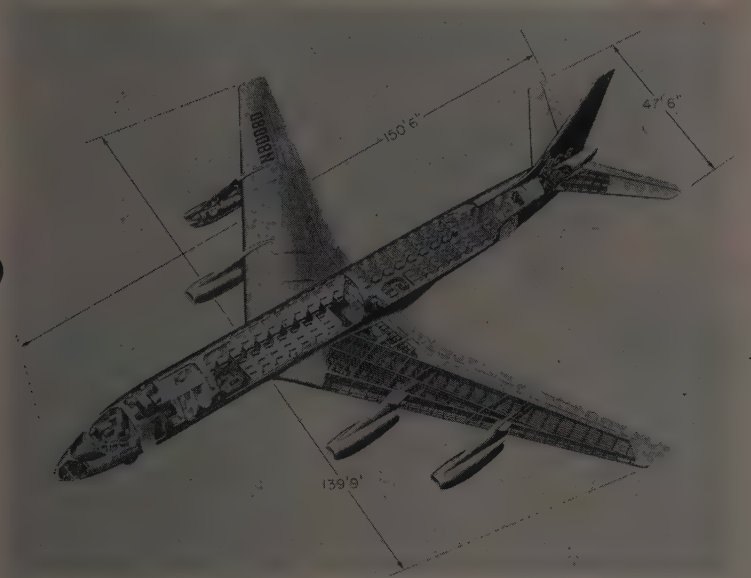

FIRST FLIGHT of DC-8 (top) took place on May 30, 1958. CAA certification is expected for this August. To carry its higher fuel load (21,615 instead of 17,600 gal), international version will have thicker skin and stringer material in wing, aft fuselage, and tailplane. Tread is 20 ft, 10 in.; height over tail, 42 ft 4.2 in.

design progress

by Irwin Stambler
Associate Editor

DC-8 structure: New fail-safe approaches

DC-8 STRUCTURE features a number of different approaches to preventing fatigue problems. One is the use of the largest possible wing skins—since, according to Douglas Aircraft Corp., Santa Monica, Calif., fatigue problems usually occur at joints. Selection of rivet patterns was also deemed critical. Titanium "rip stoppers" were used around most cutouts and frames. Takeoff gross weights are 265,000 lb for the domestic version, 287,000 lb intercontinental, and 310,000 for extended range. Maximum operating ranges are, respectively, 3900, 4500, and 5200 miles. Normal cruise speed is about 550 mph., top cruise speed, about 580 mph. Seating capacity can range from 118 to 176. Domestic version is powered by four P&WA JT3s (J57s); the intercontinental version, by P&WA JT4s (J75s) or Rolls-Royce Conways.

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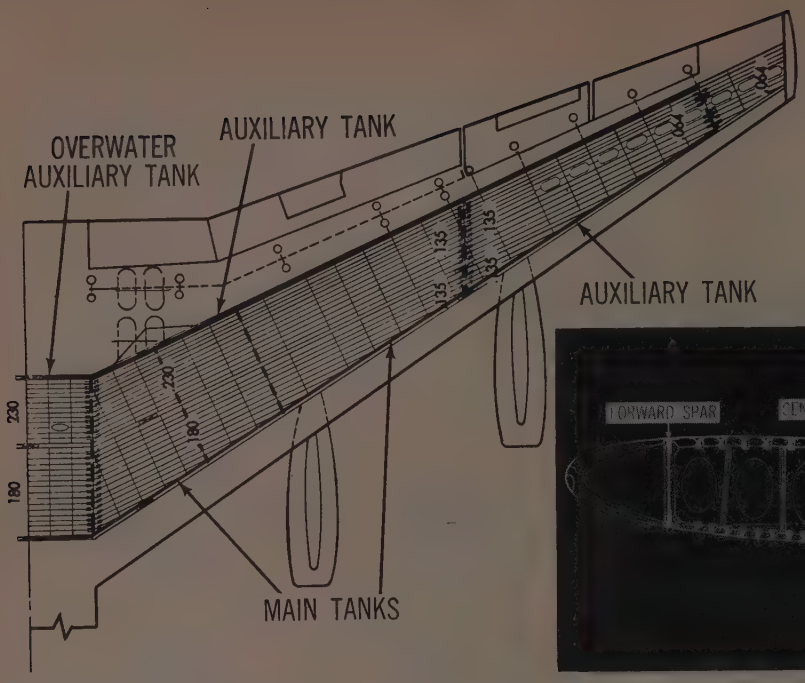
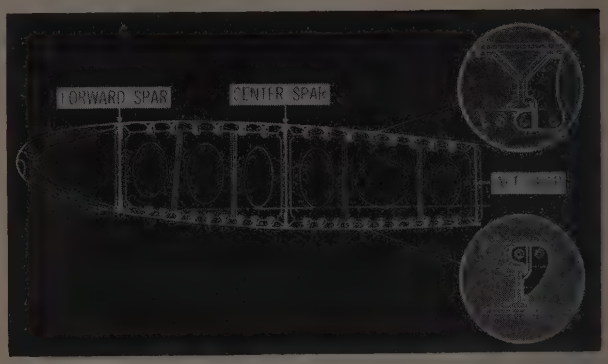
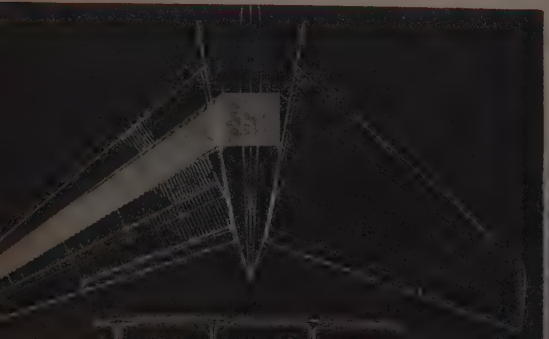


design progress

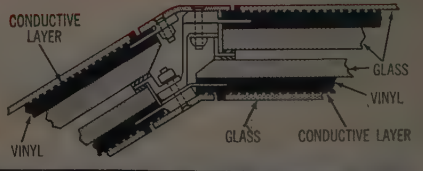


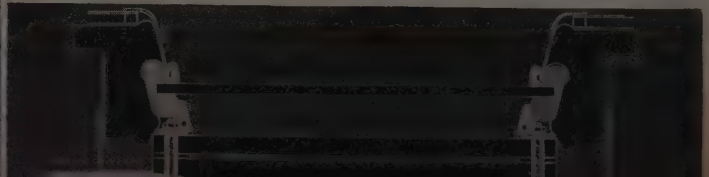
WING LAYOUT with skin gages (left). No integral stiffening is used. All wing skins are 7075 aluminum, as is most of the internal wing structure. Largest skins, used to eliminate spanwise joints, were made from 10-48-ft clad sheet taper-rolled to keep cladding on. For better fatigue design, dihedral joint was also eliminated and wing sections were joined at the fuselage centerline. Sheet had to be formed in W-condition and were shipped to Douglas' plant at Santa Monica in SW-condition stacked in an icebox. Right: Typical wing rib section shows use of Y-sections, which eliminates the need for blind riveting, angle attach, etc.

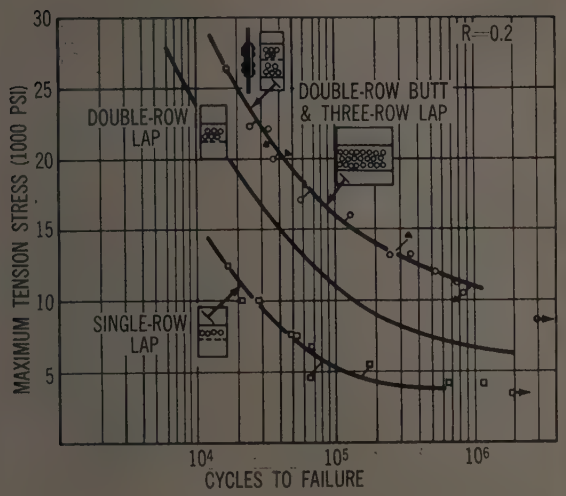
FORMING of skins to get dihedral bend required press with twice the tonnage of the largest stretch press ever before used in U.S. (skin is ¼ in. thick at this point), so Douglas had to order a special press (left). To achieve continuous structure through dihedral area, large forgings (right) are used to tie into three main spars.



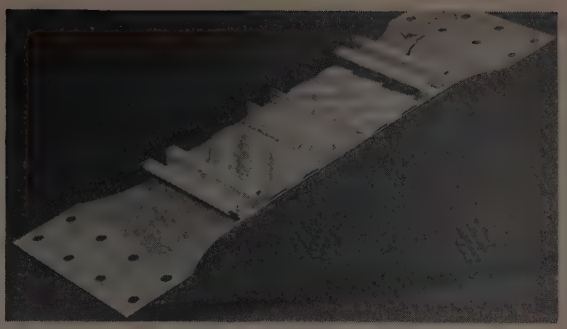
HORIZONTAL stabilizer (left) and typical window designs for passenger cabin (bottom) and cockpit (right).

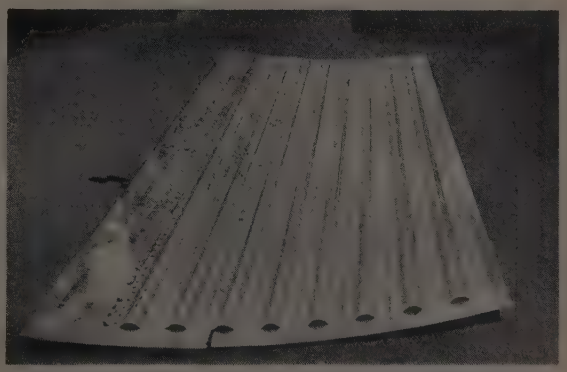


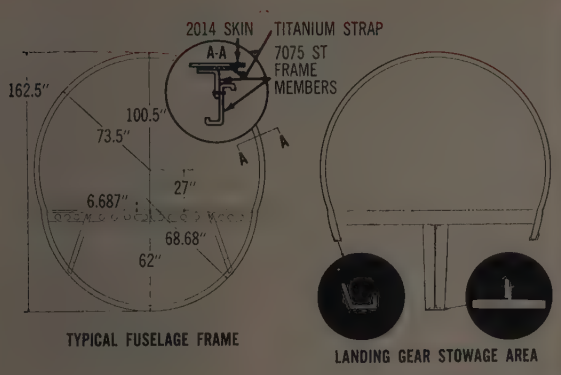


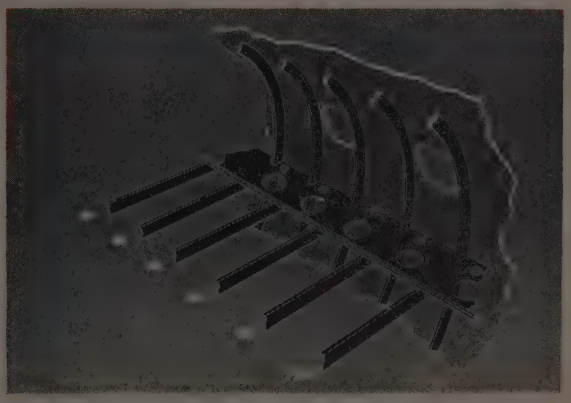


RIVET PATTERN tests provided graph used in design of fuselage splices. Douglas chose a butt-type splice (top right) with wide 75 ST doublers extending to adjacent stiffeners and extruded 75 ST center stringer. Skins are 2014 aluminum, which showed lowest crack propagation rate in tests. Throughout the aft fuselage, they are made of 0.08-in. aluminum. Twice as many stringers are used in the front than in the aft section, for Douglas decided on heavy structure for noise insulation rather than lead shielding as on the DC-6 and -7. Right: Typical skin section.

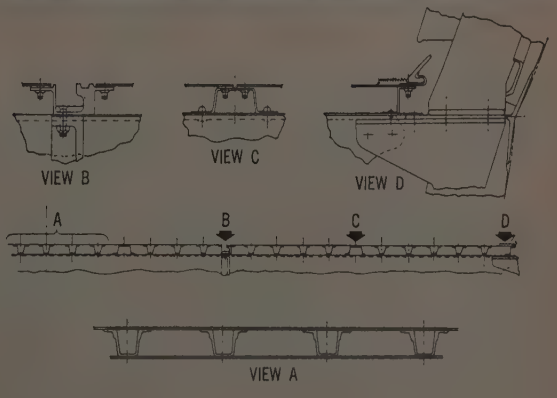








TITANIUM STRAPS are used on all DC-8 frames (above) to act as "rip stoppers," since in tests cracks never started in titanium. Douglas engineers state use of titanium provides much more effective fail-safe structure than any other method. Titanium is used around most fuselage and wing cutouts every door has a wide titanium doubler around its opening. Alloy is 6Al-4V or A110AT. Top right: Floor beam arrangement. Bottom right: Hat sections used under metal floor to insulate cabin from cold substructure and details of seat installation.



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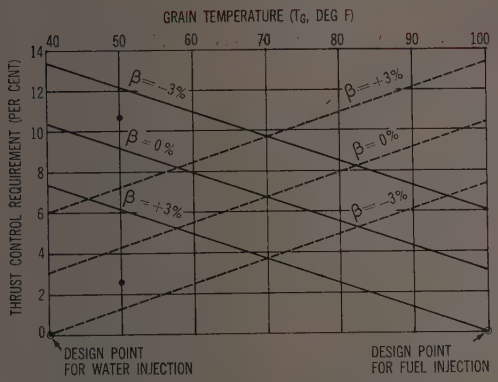

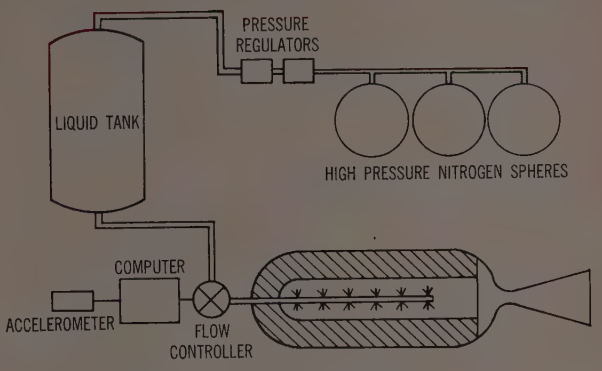

EFFECT of grain temperature and batch-to-batch variance (β) and designs points are for the case of a typical medium range, solid propellant ballistic missile (left). For another engine with $T_G = 50$ deg F and $\beta = -1.5$ per cent, the thrust must be reduced to the design point by 2.7 per cent with water injection or raised by 10.6 per cent with fuel injection. Right: Typical liquid injection system. The volume of the tank depends on that of the liquid and, together with the pressure requirement, determines the weight of the nitrogen.

Liquid injection for solid rocket thrust control

There is no debate about the desirability of thrust control for solid propellant rockets. What is debated, though, is which of several conceivable methods is best for the job. One of them is evaluated in this article for the case of a typical medium range ballistic missile.

by Michael Grenus, Senior Preliminary Design Engineer, Defense Operations Div., Chrysler Corp.*

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THRUST CONTROL for solid propellant rockets is needed first of all because we cannot yet produce propellants that are insensitive to operating temperature and do not vary from batch to batch in mixture and energy content. The advantage in achieving this control by liquid injection is that this method is based on the controllability of fluid flow. The drawback is that mechanical thrust control probably imposes less of a weight penalty.

Liquid injection essentially changes the internal ballistics of the combustion system and so affects the energy available in the rocket nozzle for expansion. Many liquids, meeting the logistic requirements and being compatible with the solid propellant, can be used in

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Table I: Change of Thrust Equation Variables with Liquid Injection

χ	$\frac{(\sqrt{T_c/\bar{M}_{Ls}})_\chi}{(\sqrt{T_c/\bar{M}_{Ls}})_o}$			$\frac{(\sqrt{\eta})_\chi}{(\sqrt{\eta})_o}$			$\frac{(\sqrt{\lambda/\lambda-1})_\chi}{(\sqrt{\lambda/\lambda-1})_o}$			$\frac{(W_T)_\chi}{(W_T)_o}$		
	H_2O	$(CH_2)_2O$	$H_2O_2+H_2N\cdot NH_2$	H_2O	$(CH_2)_2O$	$H_2O_2+H_2N\cdot NH_2$	H_2O	$(CH_2)_2O$	$H_2O_2+H_2N\cdot NH_2$	H_2O	$(CH_2)_2O$	$H_2O_2+H_2N\cdot NH_2$
0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
0.02	0.9704	0.9963	1.0037	1.0	0.9991	0.9986	1.0	1.0016	1.0010	1.0041	1.0302	1.0332
0.04	0.9427	0.9927	1.0075	1.0	0.9979	0.9979	1.0	1.0032	1.0019	1.0096	1.0613	1.0680
0.06	0.9166	0.9893	1.0112	1.0	0.9970	0.9972	1.0	1.0048	1.0029	1.0165	1.0942	1.1049
0.08	0.8918	0.9860	1.0150	1.0	0.9959	0.9965	1.0	1.0065	1.0039	1.0246	1.1290	1.1437
0.10	0.8680	0.9828	1.0187	1.0	0.9949	0.9957	1.0	1.0081	1.0048	1.0339	1.1652	1.1844
0.12	0.8451	0.9796	1.0219	1.0	0.9939	0.9950	1.0	1.0098	1.0058	1.0439	1.2034	1.2274
0.14	0.8231			1.0			1.0			1.0556		

this application—either to reduce the thrust by absorbing heat for vaporization, as in the case of such non-fuels as water, liquid CO_2, liquid Freon, etc., or to increase the thrust, as in the case of liquid fuels. The choice among them will depend largely on weight considerations.

Liquid injection into the combustion chamber of a solid rocket will affect all the five variables that determine thrust: combustion temperature (T_c, in degrees R), chamber pressure (P_c, in psia), mean molecular weight ($\bar{M}$, in lb/mol), and specific heat ratio of the gases (λ) in the chamber, and total weight flow rate through the nozzle ($\dot{W}_T$). An analysis of any given liquid injection medium must be based on the changes it produces in these variables.

By derivation from the basic equations of solid propellant rocket combustion and making certain simplifying assumptions (causing only negligible errors), we can derive the following expressions for these changes:

(1) $$\dot{W}_T = aP_c^n A_s \rho/(1-\chi),$$

where a is burning rate coefficient; n, burning rate exponent; A, average burning area (in square inches); ρ, density (in lb/cu. in.); χ, ratio of liquid flow rate to total flow rate; and subscript s refers to the solid propellant;

(2) $$T_{c(non\text{-}fuel)} = \{c_{ps}T_s(1-\chi) - \chi[\Delta H_L + \Delta H_v + f(T_c) (T_c - T_v)]\}/[c_{ps}(1-\chi) + f(T_c)\chi],$$

(3) $$T_{c(fuel)} = [c_{ps}T_s(1-\chi) - c_{pL}T_L\chi]/[c_{ps}(1-\chi) + c_{pL}\chi],$$

where c_p is specific heat at constant pressure (in btu/lb deg R); T_s, solid propellant combustion temperature (in deg R); H, enthalpy (in btu/lb); T_v, liquid vaporization temperature; and the subscripts L and v refer, respectively, to the injected liquid and its vaporization (in the case of non-fuels);

(4) $$P_c = ([aA_s\rho R'T_c/V_c]\{\chi/[\bar{M}_L(1-\chi)] + 1/\bar{M}_s\})^{1/(1-n)},$$

where R' is the universal gas constant, or 1544 ft-lb/-deg F/mol; V_c, volume of gas flow rate (in cu ft/sec); and the values of $\bar{M}$ are assumed to be constant;

(5) $$\bar{M}_{Ls} = \bar{M}_s(1-\chi) + \bar{M}_L\chi,$$

where subscript Ls refers to the mixture of solid propellant and liquid products;

(6) $$\lambda_{Ls} = \lambda_s(1-\chi) + \lambda_L\chi.$$

P_c enters into the expression for ideal cycle efficiency:

(7) $$\eta = 1 - (P_e/P_c)^{(\lambda-1)/\lambda},$$

where P_e is nozzle exhaust pressure (in psia). For simplicity's sake, we will assume P_e/P_c to be constant—the error will be negligible, since nozzle gas separation, the phenomenon we are ignoring, occurs only over a fraction of the burning period and with extremely reduced P_c.

With the expressions we have derived for four of the variables in the thrust equation:

(8) $$F = \sqrt{(2R'/g)[\lambda/(\lambda-1)](T_c/\bar{M})[1-(P_e/P_c)^{(\lambda-1)}]}\,\dot{W}_T,$$

and with P_e/P_c constant, we can now determine the thrust variation at a value χ of liquid injection:

(9) $$F_\chi/F_o = [(\sqrt{T_c/\bar{M}_{Ls}})_\chi/(\sqrt{T_c/\bar{M}_{Ls}})_o][(\sqrt{\eta})_\chi/(\sqrt{\eta})_o] [\{\sqrt{\lambda/(\lambda-1)}\}_\chi/\{\sqrt{\lambda/(\lambda-1)}\}_o][\dot{W}_{T\chi}/\dot{W}_{To}].$$

A plot of each factor on the right-hand side of this equation against the percentage of fuel injection shows the relative importance of each variable in the thrust change. Generally, changes in T_c and $\dot{W}_T$ will have the greatest effect. Changes in P_c, influenced by changes in T_c, will affect primarily $\dot{W}_s$, while the effect on η will be slight. Large differences between M_s and M_L will be a major factor. The change in λ will be small and its effect on the thrust smaller yet; in most cases, λ can be assumed to be constant.

Numerical comparison shows penalties

The weight penalties caused by liquid injection are best shown by a numerical comparison. For this we will use water, which absorbs heat by evaporation, ethylene oxide [$(CH_2)_2O$], a monopropellant adding heat by decomposition, and a bipropellant system of 99.6 per

$\frac{(I_{sp})_\chi}{(I_{sp})_o}$			$\frac{(F)_\chi}{(F)_o}$		
H_2O	$(CH_2)_2O$	$H_2O_2+H_2N\cdot NH_2$	H_2O	$(CH_2)_2O$	$H_2O_2+H_2N\cdot NH_2$
1.0	1.0	1.0	1.0	1.0	1.0
0.9704	0.9970	1.0033	0.9744	1.0271	1.0366
0.9427	0.9938	1.0073	0.9517	1.0547	1.0758
0.9166	0.9911	1.0113	0.9317	1.0844	1.1174
0.8918	0.9883	1.0154	0.9137	1.1158	1.1613
0.8680	0.9857	1.0192	0.8974	1.1485	1.2071
0.8451	0.9832	1.0227	0.8822	1.1831	1.2552
0.8231			0.8686		

cent hydrogen peroxide and hydrazine ($H_2O_2+H_2N\cdot NH_2$), which adds heat by combustion. We will further assume a typical medium thrust rocket with the following design data: P_c, 500 psia; P_e, 10 psia; burning time (t), 38.74 seconds; $\dot{W}_s$, 178.4 pps; specific impulse (I_{sp}), 221.5 seconds; F, 39,515 lb; I, 1.531×10^6 lb-sec; A_s, 12,080 sq in.; and W_s, 6911 lb. The properties of the solid propellant and its gas products are taken as: a, 0.0372; n, 0.3; λ, 1.25; c_{ps}, 0.397; ρ, 0.0615; T_c, 4716 deg R; M_s, 25.

T_c in terms of χ for water injection is found from *Equation 2*, where ΔH_L and ΔH_v for conversion of 60-deg F water to 457-deg F saturated steam are, respectively, 421 and 755 btu/lb and the average c_p for steam from 60 deg F to T_c, at T_c in the range of 3000-4500 deg F is about $32.895\times10^{-6}T_c+0.4434$. After insertion of these values and the design data, *Equation 2* reduces to:

$$T_c=\{1872.252(1-\chi)-\chi[1176+(32.895\times10^{-6}T_c+0.4434)(T_c-927)]\}/[0.397(1-\chi)+(32.895\times10^{-6}T_c+0.4434)\chi]. \quad (10)$$

P_c at χ is computed from *Equation 4*, after V_c has been found (from the solid propellant data) as 103,921 cu ft/sec. It reduces to:

$$P_c=\{[0.0228\chi/(1-\chi)+0.01643]T_c\}^{1.4286}, \quad (11)$$

where T_c is the value at χ.

M_{Ls} is computed from *Equation 5* as $25(1-\chi)+18\chi$. The specific heat ratio for water vapor over the T_c range we are dealing with is about that of the solid propellant gases and can be assumed to be constant at 1.25. The ideal cycle efficiency therefore is constant, too (at constant P_e/P_c).

The solid propellant weight flow rate is computed from:

$$\dot{W}_s=aP_c^nA_s\rho, \quad (12)$$

where P_c is the value at χ, and is found to be $27.64P_c^{0.3}$. $\dot{W}_T$ and $\dot{W}_L$ can now be calculated from:

$$\dot{W}_T=\dot{W}_s/(1-\chi), \dot{W}_L=\chi\dot{W}_T. \quad (13)$$

Similar calculations are made for $(CH_2)_2O$ and $H_2O_2+H_2N\cdot NH_2$, using their gas properties at the design P_c of 500 psia. Their results are: $(CH_2)_2O$—T_c, 2215; $\overline{M}_L$, 12.86; c_{pL}, 0.646; λ 1.2; $H_2O_2+H_2N\cdot NH_2$—T_c, 5150; $\overline{M}_L$, 19; c_{pL}, 0.579; λ, 1.22. The decomposition and combustion products, respectively, of the two liquids are assumed to mix physically with the solid propellant gas products without further combustion of dissociation.

The values of T_c, P_c, $\overline{M}_{Ls}$, η, λ, $\dot{W}_s$, $\dot{W}_L$, and W_T can now be tabulated in terms of χ for the three liquids. *Table I* further shows the computed changes in these thrust equation variables, in I_{sp}, and in thrust for liquid injection at values of χ from zero to 14 per cent. Interestingly enough, practically no change in I_{sp} results for our hypothetical engine from $(CH_2)_2O$ injection, and the increase in thrust equals that in $\dot{W}_T$. In practice, I_{sp} would increase if there were excess oxygen in the solid propellant gas products to burn the $(CH_2)_2O$ decomposition products.

The range of thrust control is determined by the initial grain temperature (T_G) limits and the batch-to-batch variance of the grain energy content. The propellant's t and characteristic velocity (C^*) vary with pre-ignition T_G and so, therefore, does thrust.

The thrust varaition with the deviation of T_G from its nominal design value (T_o) can be expressed by the factor $e^{(\sigma+m)(T_G-T_o)}$, where σ and m are temperature sensitivity factors for t and C^*, respectively, and T_G (in degrees F) is the value at firing. For the propellant in our example, $T_o = 70$ deg F, $\sigma = 0.001$, and $m = 0.0002$. Thus the thrust is proportional to $e^{0.0012(T_G-70)}$.

The T_G limits are specified by the manufacturer, but the design temperature range depends on the vehicle logistics. For our engine, we'll assume a permissible T_G range of +40 to +100 deg F. From this we can work out the limits of the thrust control needed to offset T_G variations as ±3.67 per cent.

The batch-to-batch variance (β) is caused by manufacturing tolerances, and its effect on the thrust equation parameters is indeterminant. Therefore it is expressed directly in terms of net thrust variation. Its value usually is given by the manufacturer; for an engine of the size we are discussing, we'll assume it to be ±3 per cent.

Thrust and burning time changed

If the engine must produce a constant thrust at any condition within the range of T_G and β, the design point for thrust control must be at the upper limit of the range ($T_G = +100$ deg F and $\beta = +3$ per cent) with fuel injection and at the lower limit ($T_G = +40$ deg F and $\beta = -3$ per cent) with water injection. In either case, the maximum thrust control requirement is 13.34 per cent (see *Graph*).

To accommodate these design points, we must change the nominal thrust and burning time design parameters of the engine, which are for $T_G = +70$ deg F and $\beta = 0$ per cent. Design thrust is increased by three per cent to 40,700 lb, which decreases t to 37.62 seconds.

The propulsion system weight penalties are computed at the design points of the *Graph*, or the maximum thrust control of 13.34 per cent. For water injection at this condition, we find $\chi = 14.3$. From the tabulation of the thrust equation variables, we further find $\dot{W}_s = 161.7$ pps. However, for $T_G = +100$ deg F, this value must be raised by 3.67 per cent to 167.6 pps.

more on page 63

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Table II: Estimated Liquid System Weight for Maximum Thrust Control Requirement (lb)

	Water	Ethylene Oxide $(CH_2)_2O$	Hydrogen Peroxide-Hydrazine $H_2O_2 + H_2N\,NH_2$
Storage Tank	187	138	110
Nitrogen & spheres	296	291	169
Thrust measurement & control system	20	20	20
Injector, regulators, plumbing, etc.	35	31	21
Total fixed weight	538	480	320
Liquid weight (W_L)	1052	676	486
Total liquid injection system	1590	1156	806
Weight of required solid propellant (W_s)	6621	7103	7099
Nominal design propellant weight	6911	6911	6911
Difference between nominal and required propellant weights	−290	192	188
Total propulsion system weight increase (W_e)*	1300	1348	994
Total missile system weight increase	2808 (24.4%)	1834 (15.9%)	1242 (10.8%)

*The weight increase of the rocket engine case due to combustion chamber pressure and temperature increase with fuel injection is not included.

We can now calculate the weight of the required water from $\dot{W}_L = \dot{W}_s\,\chi/(1-\chi)$ as 1052 lb.

$\dot{W}_s$ is at a maximum at $T_G = +100$ deg F and $\beta = -3$ per cent, at which χ equals 6.55 per cent for 7.34 thrust control. For this value of χ, the propellant requirement (W_s) is 6621 lb.

Similar calculations can be made for $(CH_2)_2O$ and $H_2O_2 + H_2N{\cdot}NH_2$, for both of which the tabulated $\dot{W}_s$ value must be decreased by 3.67 per cent for $T_G = +40$ deg C. For maximum $\dot{W}_s$—at the design point of the *Graph* —χ is 4.35 per cent for $(CH_2)_2O$ and 3.2 per cent for $H_2O_2 + H_2N{\cdot}NH_2$ for six per cent thrust control in both cases.

Table II shows the results of the weight calculations. We can see that $H_2O_2 + H_2N{\cdot}NH_2$ imposes the smallest propulsion penalty and that water looks better than $(CH_2)_2O$ because of the reduction it causes in the solid propellant weight needed for constant thrust.

The weight added to the propulsion system, together with the change in I_{sp}, affects the required missile mass ratio. The range of a ballistic missile is given by:

$$(14) \qquad V_{co} + f(D) + f(g) = I_{sp} g \ln[W_o/(W_o - W_s)],$$

where V_{co} is cutoff velocity; D, drag; W_o, takeoff weight; and $W_o(W_p - W_s)$, the mass ratio. As the weight of the liquid injection system is added to the missile, more fuel is needed to achieve V_{co}. The weight of this extra fuel (and of the corresponding additional thrust control) again is added to the missile weight, and another incremental amount of fuel is required. These additions continue, in a diminishing manner, until a mass ratio is reached that will meet the V_{co} requirement.

Since we are concerned with relative weight penalties, we can use a first-order numerical approximation to find the missile weight added by this process. For simplicity's sake, we will also neglect the effect of the increase in t (caused by the addition of fuel) on trajectory and range.

Weight additions can be computed

Assuming an original mass ratio of 2.5 and no change in the drag and pitch program, we can compute V_{co} as 6535 fps and the original takeoff weight (W_o) as 11,518 lb. After inserting these values in *Equation 14*, we can compute the weight additions from:

$$(15) \qquad 6535 = 32.3 I_{sp1} \ln[(W_o + W_e + W_{s1} + W_{L1})/(W_o + W_e - W_s - W_{s1} - W_{L1})],$$

where I_{sp1} is the value at χ for maximum thrust control; W_e, total propulsion system weight increase; W_s, the value for the original burning time; W_{s1}, the additional solid propellant needed because of the addition of W_e; and W_{L1}, the additional liquid injection required for W_{s1} (and expressed as $W_{s1}W_L/W_s$). The fixed equipment of the liquid injection system we'll assume remains constant. The values of χ for this computation are 14.3 per cent for water, 9.1 per cent for $(CH_2)_2O$, and 6.72 per cent for $H_2O + H_2N{\cdot}NH_2$. *Table II* shows the results of the computation.

It must be noted that, instead of the $H_2O_2 + H_2N{\cdot}NH_2$ injection system, other bipropellant combinations could have been chosen for our comparison. For instance, the high energy boron fuels now under development offer some promise as injection mediums and may lead to thrust control systems competitive in weight with mechanical methods.—End

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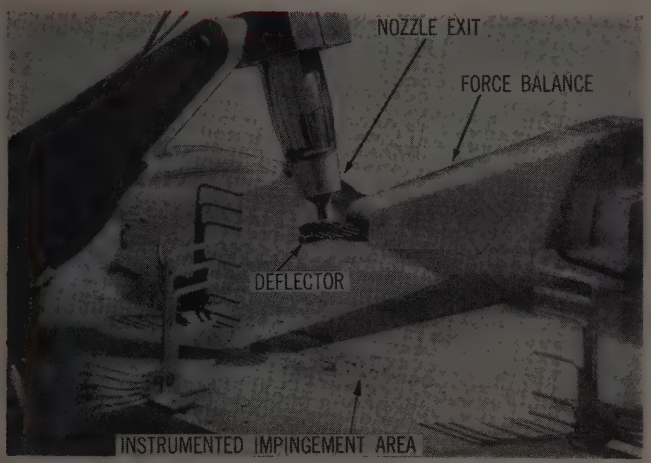


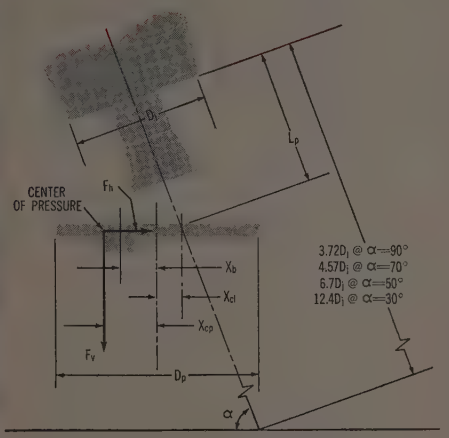


FIGURE 1: Tenth-scale model and test nomenclature used by Northrop in development of its jet deflector for Hawk launchings. Without deflectors, the jet may erode a hole in the ground, causing the launcher to slip.

Designing a jet deflector for the Hawk launcher

A missile whose exhaust blasts such a hole in the ground during launch that the launcher slips out of position is obviously self-defeating. To overcome the danger of soil erosion for the Hawk—fired from unprepared positions—Northrop therefore had to design a deflector that would render the exhaust blast harmless.

by J. A. Quinville, Engineering Specialist,
Norair Div., Northrop Corp.[1]

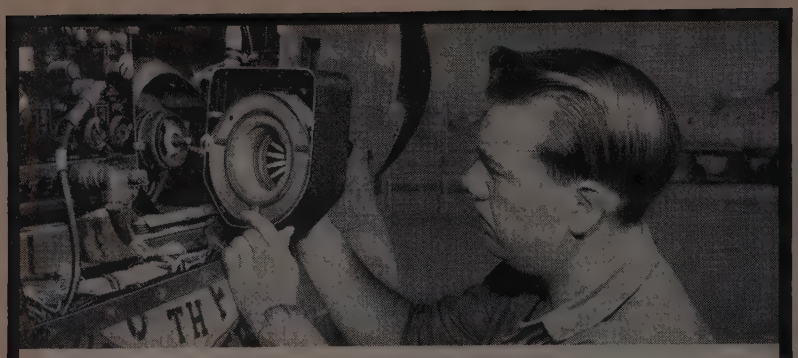
WHEN the Army's Raytheon Hawk ground-to-air missile is fired from its mobile launcher at an angle of 70 deg, its booster jet can erode a fairly large hole in the ground near the launcher legs. In loose sand, for instance, a hole about six feet in diameter and 1½ ft deep at the center has been measured after the firing of a single round of Hawks.

As a mobile weapon, the Hawk must be launched from essentially unprepared positions. On the other hand, its launcher cannot be shifted more than five degrees before realignment with the radar ground guidance is necessary. Soil erosion from the booster jet therefore posed a serious operational prob-

more on next page

(1) Norair Div., Northrop Corp., 1001 E. Broadway, Hawthorne, Calif. This is a condensation of a paper, "A Diffuser Type Jet Deflector for the Hawk Launcher," given before the Bumblebee Aerodynamics Panel at the University of Texas last Sept. 30.

FIGURE 2: Slotted jet deflectors developed for the Hawk launcher.



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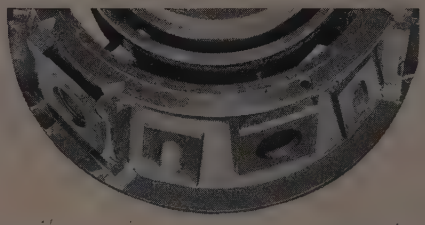

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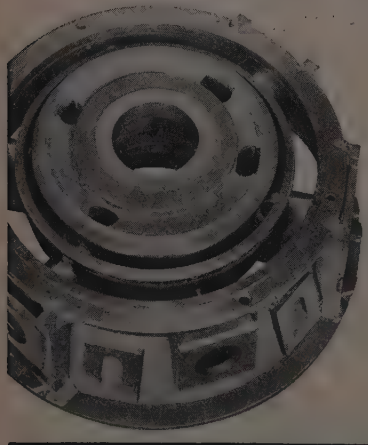

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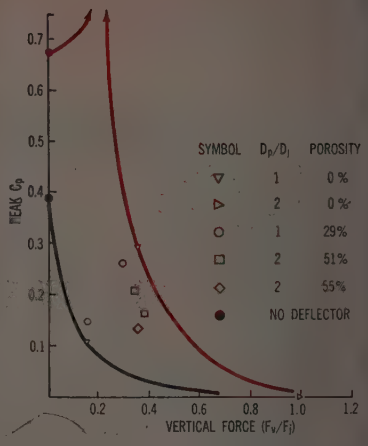

FIGURE 3: Efficiency of circular-hole deflectors at $L_p/D_j=1$ and launch angles (α) of 90 (black) and 70 deg (red). Curves show values for solid deflectors.

lem. To overcome it, Northrop—responsible for the system design of the launcher under contract to Raytheon, which is responsible for the overall weapon — developed a diffuser-type jet deflector.

The diffuser is a flat, circular plate that has longitudinal slots and is mounted about 15 in. below the initial position of the missile nozzle exit (*Fig. 2*). It can be trained throughout 360 deg in azimuth and adjusted horizontally for all launch angles. It requires no setup time and adds only slightly to the launcher weight.

To develop our diffuser, we used a tenth-scale model (*Fig. 1*). A pressure-instrumented plate represented the ground. Since both soil erosion and ground surface pressure are at a maximum at the point of jet impingement, this pressure could be used as a measure of erosion. With the jet exit diameter (D_j) at one-tenth scale, jet shape and diamond pattern were at the same scale and inpingement loads at one-hundredth scale.

Solid body simulated the sustainer nozzle

The stationary nozzle we used could lead only to negligible errors, since the missile speed during the erosion period is near zero, while the jet speed is above 2000 fps. The extended nozzle of the sustainer engine, which is inoperative during launch, was simulated by a solid centerbody. As pressure, jet speed and shape, and hence the

more on page 71

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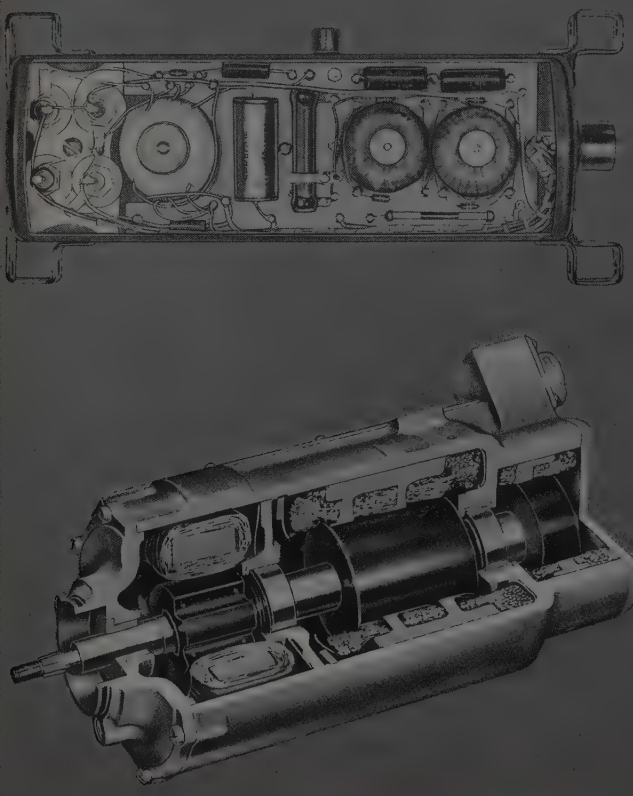

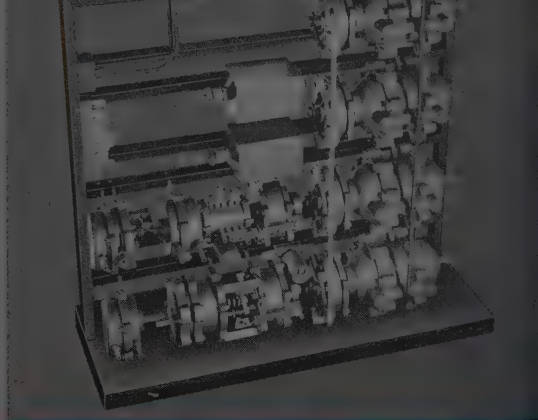

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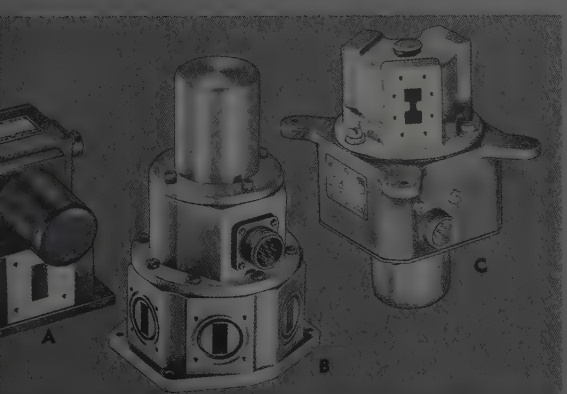

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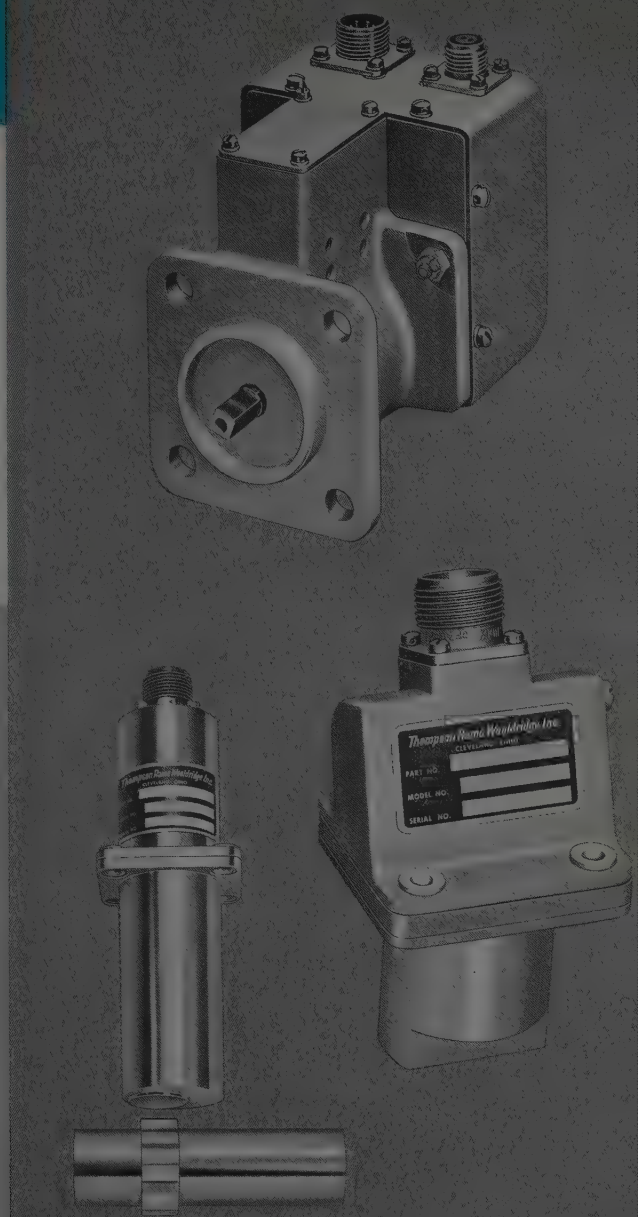
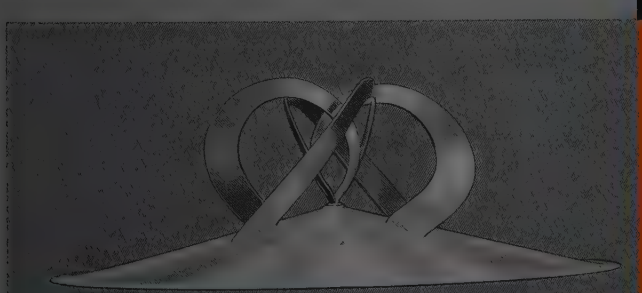


Magnetic speed sensing devices developed and produced by TAPCO Group for high-speed applications up to 100,000 rpm. Designs eliminate need for slip-rings, rotating permanent magnets, and complicated fly-ball mechanisms.



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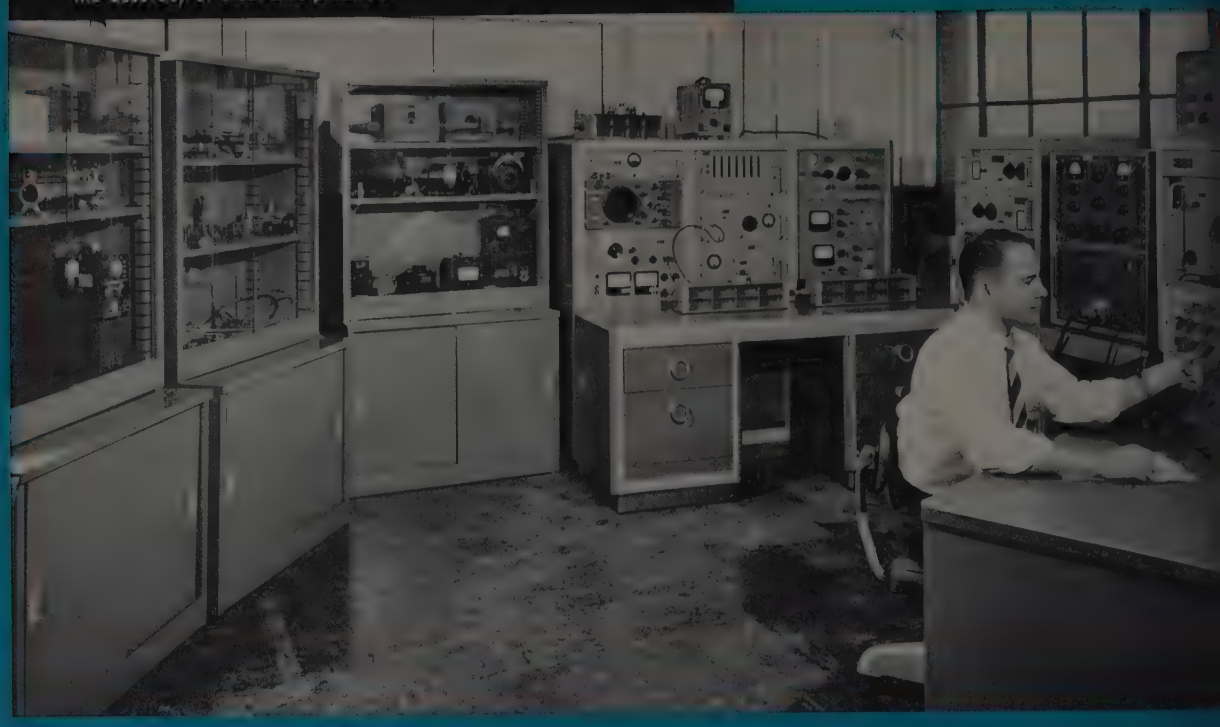

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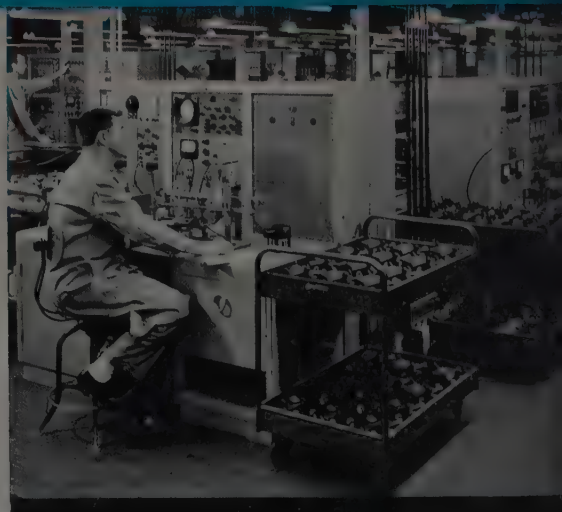

Production testing of microwave components at

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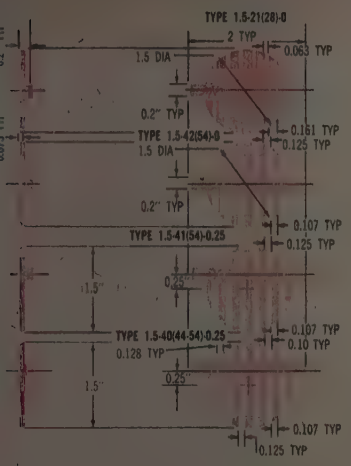

FIGURE 4: Slotted deflector designs. In the notation used for these deflectors, the first number gives D_p/D_j; the second, the overall porosity percentage; the parenthetical one, the local porosity, or ratio of slot width to spacing; and the last, the support bar shift (X_b/D_j). In the case of two parenthetical numbers, the first gives the local porosity forward of the bar and the second the value for the aft area.

Mach number, loads are all independent of temperature, we did not attempt to duplicate the actual static jet exit temperature—the model's total jet temperature always equaled the ambient temperature.

The accuracy of our measurements with this model, we estimated, was ±2 per cent for total jet pressure, ±1 per cent for deflector forces, and ±0.01 and ±0.001 for pressure coefficients above and below 0.1, respectively. We tested solid deflector plates, porous plates with circular holes, and slotted plates. In correlating the test data, we first considered the deflector forces and then the ground surface pressure, both as affected by deflector geometry, launch angle, and deflector distance from the nozzle. Finally we considered the combined effect of deflector forces and ground pressure, which defines the deflector efficiency, or the greatest reduction of the ground pressure coefficient with the least deflector force.

Figure 3 summarizes the test results with the circular-hole deflectors, a type that in the end was rejected. The 90-deg launch angle

more on next page

Union Relays meet all requirements of Talos guidance system

The Talos, the Navy's long-range guided missile, is very important to the nation's defense. And Bendix Aviation Corporation, builder of the Talos, chose a relay made by Union Switch & Signal to meet the *extreme reliability* needs of that missile's guidance control system. That relay is the UNION miniature 6PDT.

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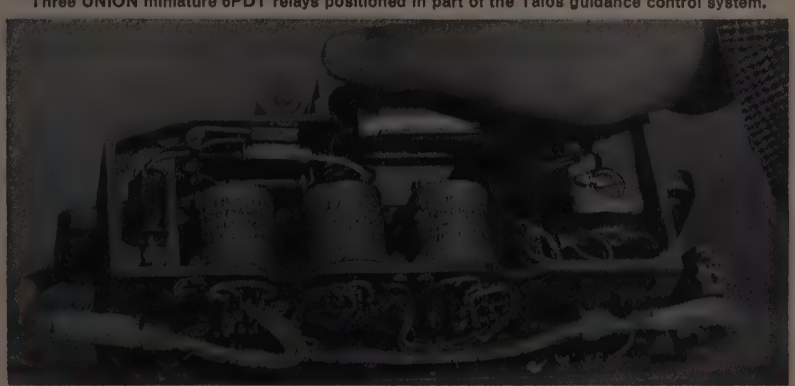

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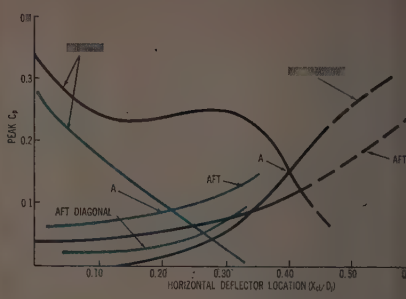

FIGURE 5: Effect of horizontal deflector location with and without shifted support bar for slotted deflectors at $\alpha = 70$ deg and $L_p/D_j = 1$. Blue curves apply to Type 1.5-41-(54)-0.25; black curves, to Type 1.5-42(54)-0.

data show that a solid deflector gives the lowest peak pressure coefficient [defined as $C_p = (P - P_o)/q_j$, where P is ground pressure; P_o, atmospheric pressure; and q_j, one-dimensional dynamic jet exit pressure] and vertical force. The 70-deg launch angle (α) data show that porosity appreciably decreases the peak C_p. The plates measuring two nozzle diameters and 51 and 55 per cent porous, respectively, give an average vertical force ratio (F_v/F_j) of about 0.38, as against 1 for a solid deflector of the same diameter. Their peak C_p is about 0.14, compared with zero for the solid plate.

Deflectors should exceed the jet diameter

Since the Hawk launcher is limited to a maximum launch angle of 70 deg, porous deflectors clearly are better than solid ones. Furthermore, the fact that the larger 2-51 and 2-55 porous deflectors[2] give a lower peak C_p than the small 1-29 deflector without an excessive increase in vertical force shows that deflectors of more than one jet diameter are desirable.

The main drawback of the circular-hole plates was that they showed a horizontal force component of about 20 per cent of the nozzle thrust. To get rid of this effect, we evolved a slotted plate design based on minimizing the side area in the vertical plane that is hit by the jet (*Fig. 4*). Most of these deflectors were designed for

(2) In this notation, the first number gives the plate-nozzle-exit diameter ratio (D_p/D_j) and the second the overall porosity percentage.

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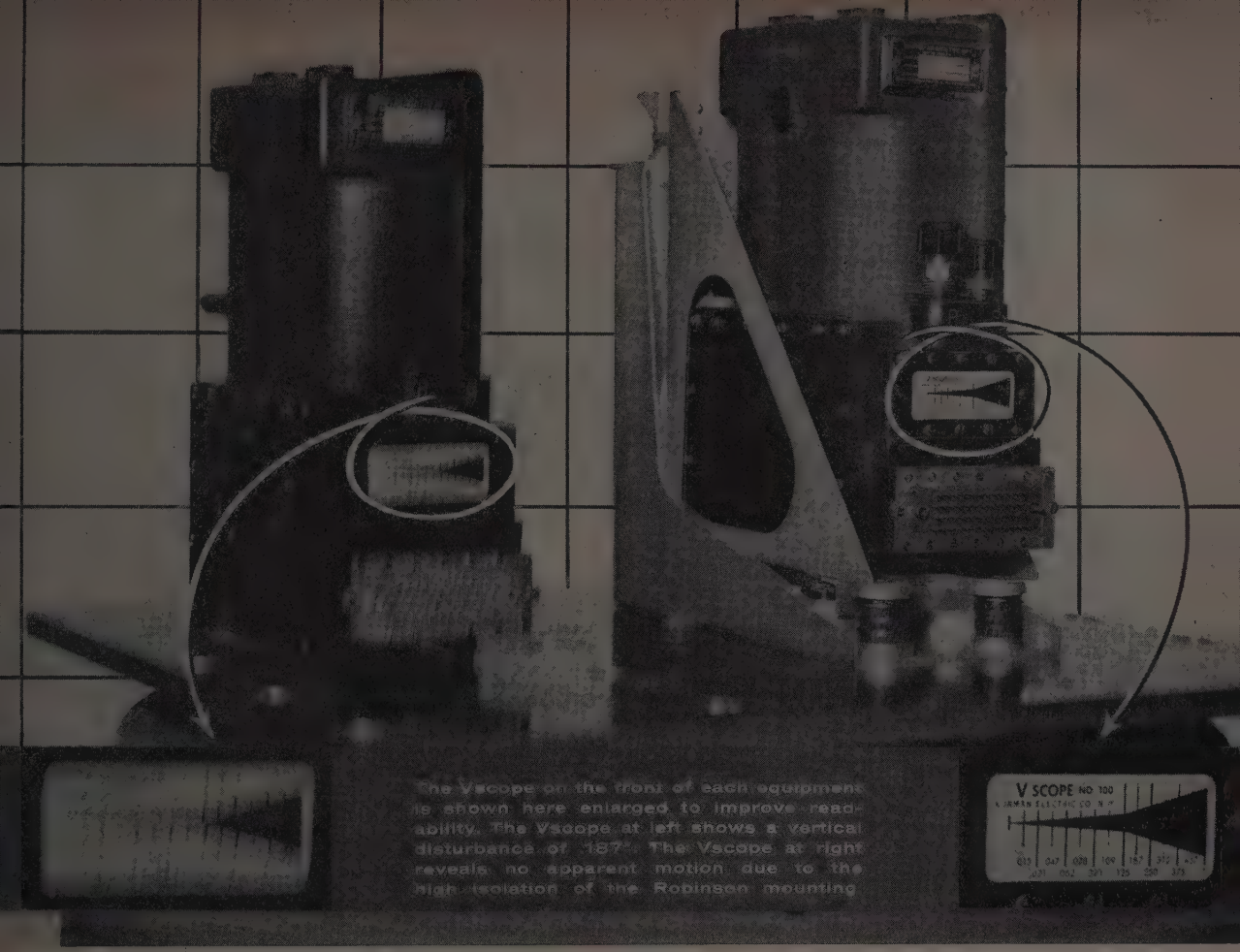

The Vscope on the front of each equipment is shown here enlarged to improve readability. The Vscope at left shows a vertical disturbance of .187". The Vscope at right reveals no apparent motion due to the high isolation of the Robinson mounting

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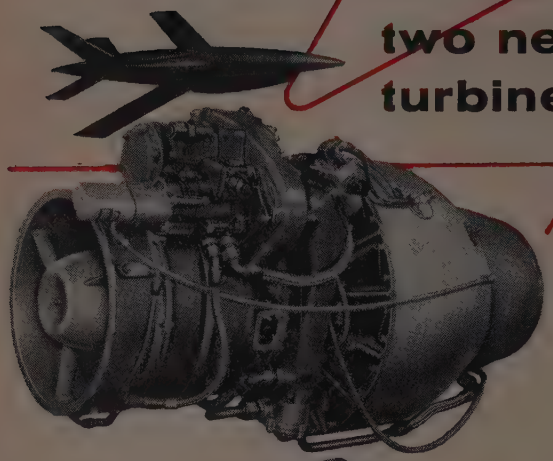

J69-T-29A

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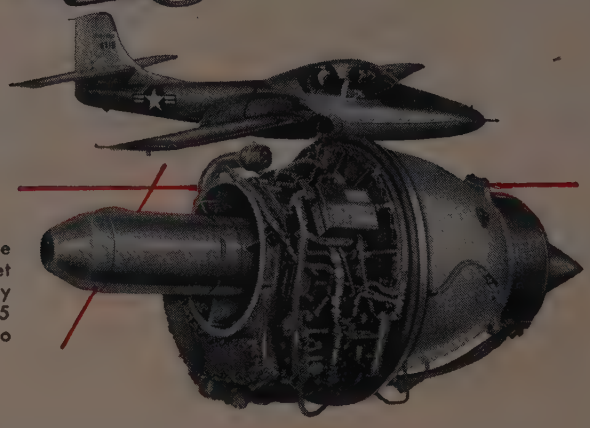

J69-T-25

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$D_p/D_j = 1.5$, which had been shown to be near optimum by the previous tests.

Figure 6 shows the effect of porosity on the vertical force for slotted deflectors as well as the effects of horizontal forward shifts of the plate (by amounts indicated by X_{cl}/D_j) and forward shifts of the support bar (by amounts indicated by X_b/D_j). The reason for the first kind of shift was that the peak ground pressure occurred on the upstream side of the plate.

As expected, the vertical force decreases as porosity increases. The forward shift of the plate luckily also reduces the vertical force. As to the shift of the support bar, we can see that, where it amounts to $0.25D_j$, it increases the vertical force by as much as five per cent for 40 per cent porous deflectors.

All our measurements of horizontal force produced small values on the same order of magnitude as the accuracy of our data. This of course was the expected result of the sharp reduction in side area.

Optimum plate location could be found

Figure 5 plots peak C_p vs horizontal deflector location for a 1.5-42(54)-0 deflector.[3] For nearly all the plates we tested, we could, by shifting the plate forward, find a minimum point such as Point A in *Figure 5*. This point indicates the best plate location. However, for the deflector in question the positioning tolerance would be small, because of the steepness of the curves about Point A.

Figure 5 also shows the effect of shifting the support bar forward by $0.25D_j$ (on a plate essentially similar to the one we have just discussed). The minimum peak C_p is reduced by about half. But this isn't all gravy—as *Figure 6* showed, the vertical force is increased by this shift. Actually the shift's main benefit is the decreased slope of the curves about Point A, indicating a much better positioning tolerance.

Figure 7 shows the efficiency of slotted deflectors as affected by horizontal shifts of the plate. We concluded from it that the best

(3) In this notation, the first number gives D_p/D_j; the second, the overall porosity percentage; the third (in parenthesis), the local porosity, or ratio of slot width to spacing; and the fourth the ratio of support bar shift (forward of the plate center) to nozzle diameter (X_b/D_j).

more on page 76

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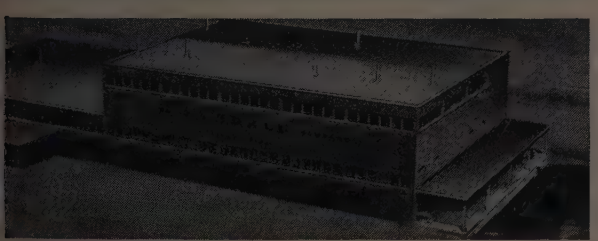

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slotted deflector should have a diameter of $1.5D_j$, an overall porosity of 50 per cent, and a local porosity of 63 per cent. The support bar should be $0.25D_j$ forward of the plate center (for better positioning tolerance) and the plate should be placed horizontally one nozzle diameter from the nozzle exit and 0.25 D_j forward of the jet centerline.

From our test data, we calculated that this design should give a peak of C_p of 0.16, or a reduction factor of 4.2, and a vertical force of 30 per cent of the nozzle thrust. The horizontal force, we figured, would be less than two per cent of the nozzle thrust.

This optimum deflector has been built and was tested once in an actual firing of a Hawk positioned on loose sand, the kind of soil in which erosion is most drastic. Unfortunately, because of a change in the Hawk nozzle made after the deflector design had been settled,

more on page 78

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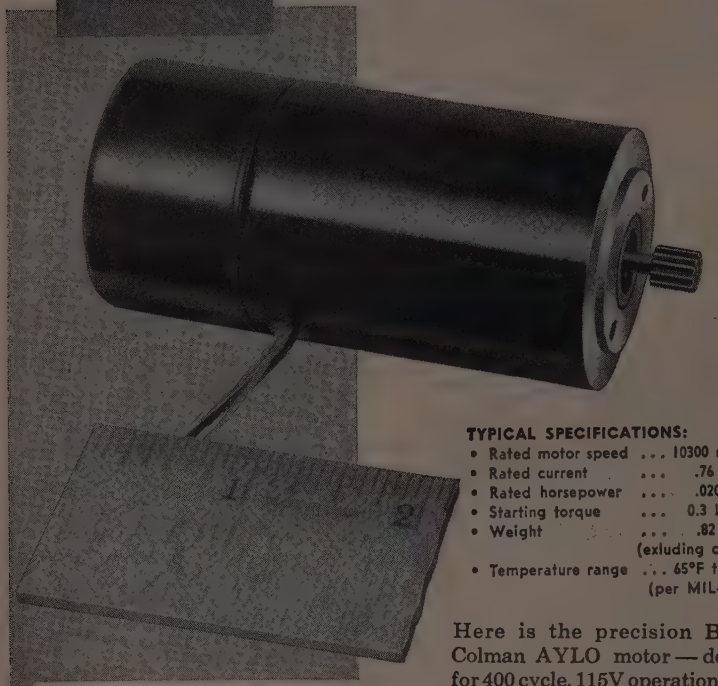

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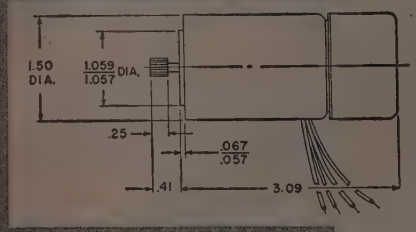

Here is the precision Barber-Colman AYLO motor — designed for 400 cycle, 115V operation. Four-pole field . . . two balanced windings permit reversal with an SPDT switch . . . unit shown has 400-cycle brake which has a minimum life of 300,000 cycles. This motor has passed MIL-M-7969a qualification tests . . . motor life 1000 hours when tested per these specifications. Write for technical bulletin.

THE WIDE LINE OF BARBER-COLMAN ELECTRICAL COMPONENTS includes: *D-C Motors* for industrial equipment and aircraft control applications. Output up to 1/10 hp . . . permanent magnet and split series types . . . various mountings and speeds . . . also available with gearheads or blowers. *Tach Generators* for accurate speed indication and servo rate control applications. *Choppers* that require extremely low driving power. *Resonant Relays* characterized by low operating power, narrow band width. *Ultra-Sensitive Polarized Relays* operating on input powers as low as 40 microwatts. *400 Cycle A-C Motors* for aircraft and missile applications.

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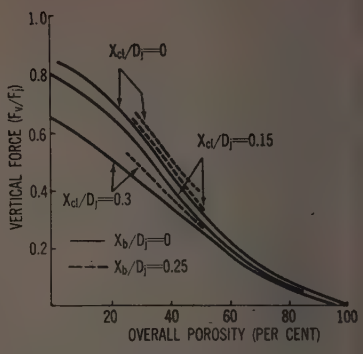


FIGURE 6: Effect of overall porosity and forward shifts of the plate (X_{c1}/D_j) and the support bar (X_b/D_j) for slotted deflectors at $\alpha = 70$ deg, $L_p/D_j = 1$, and $D_p/D_j = 1.5$.

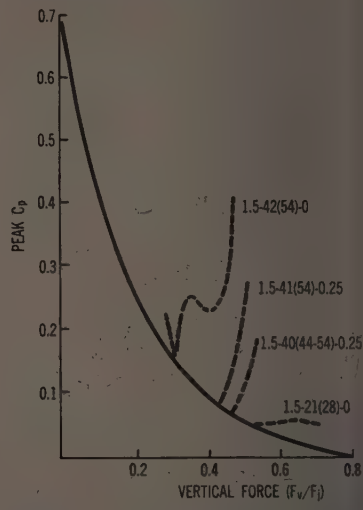
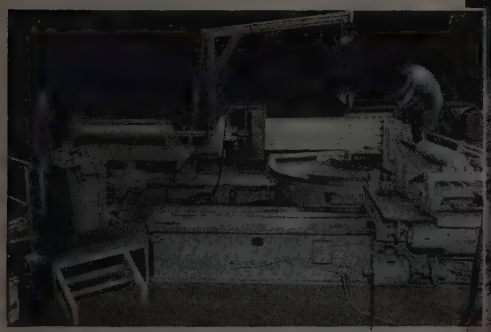


FIGURE 7: Efficiency of solid deflectors at $\alpha = 70$ deg, $L_p/D_j = 1$, and $D_p/D_j = 1.5$, showing the effect of plate shifts (dashed curves). The solid curve is drawn through the minimum peak C_p points of several deflectors, and its zero points apply to a solid deflector measuring $1.5D_j$.

the results of this first exploratory full-scale test are inconclusive.

Nevertheless, the fact that this test still resulted in considerable soil erosion makes it seem likely that more jet diffusion is needed with loose sand than is provided by the optimum deflector of our program — which, on the other hand, should prove adequate for launchings on firmer soil. For loose sand, a solid deflector measuring $1.5D_j$ certainly would be adequate, and a porous plate providing a peak C_p of about 0.05 and much less vertical force than the solid deflector may also prove satisfactory.—End

AT CONVAIR. This Model CF 25-50 Bath Radial Draw Former has produced hundreds of titanium and other critical parts for the F 102A and other programs at Convair.



AT DOUGLAS. Anti-icers, retainer seals, canopy rails, and many other parts for RB 66C, B 47 are Radial Draw Formed. DOUGLAS-TULSA STAFF PHOTO.

AT MARTIN. This Model CF 12 1/2-25 Bath Radial Draw Former forms titanium, stainless and aluminum parts for many of the Martin airplane and missile programs.

AIR PROGRESS THAT FIRES THE IMAGINATION . . .

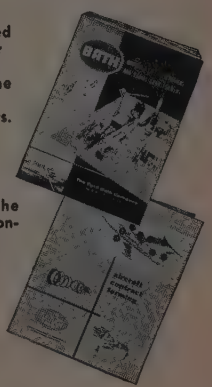
. . . and BATH radial draw formers are playing an important part

Great credit is due the aircraft, jet and missile industries for their fantastic progress in the last few years. The Aircraft Industry has taken us through the sonic barrier into the thermal thicket . . . truly, progress that fires the imagination. The titaniums, the inconels and other tough metals needed for this air progress yield best to forming by the BATH combined stretch and compression methods of Radial Draw Forming. One-piece construction in parts involving compound contours or changes in cross section throughout the contour have become possible with consequently greater strength and reduced weight.

The Cyril Bath Company is proud of the part they are playing in America's most progressive industry.

We will be pleased to send you our NEW Catalog describing the BATH Radial Draw Formers.

A Catalog describing the facilities of the Contract Forming Division is also yours for the asking.



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THE ALUMINA CARPET: SPRINGBOARD TO THE STARS...

THIS IS one of our main missile launching pads. Someday, when we have not only orbited the moon, but have sent our gleaming vessels to Mars and Venus and beyond, it may become a national shrine. With a plaque that says, in effect, "*Here it all began . . .*"

RIGHT NOW, it's not especially exciting compared to the exciting things that have happened above it —*unless* you're interested in modern industrial refractories. Then you'll notice that this pad, like other major missile-launching sites in the United States, is paved with materials containing aluminas.

WHY ALUMINAS? Because the holocaust of heat from a missile's takeoff makes the interior of a blast furnace seem cool by comparison. Because only modern ceramic technology, working with today's advanced aluminas, can produce an ideal pad that takes such a blast in its stride . . . and then stands ready, willing and eager for the *next* shoot.

NO OTHER material—in rockets or *under* them—combines such desirable attributes of high mechanical strength at high temperatures . . . outstanding dielectric properties . . . and complete transparency to electrical, magnetic and electromagnetic fields. Alcoa® Aluminas today, in radomes, insulators and flame-sprayed aluminum oxides, impart electrical, mechanical and thermal properties never before obtainable. And the strong, lightweight Alcoa Aluminum alloys themselves, of course, are more essential than ever in advanced airframe and missile production.

ALCOA offers the industry's greatest fund of experience in *all* forms and applications of aluminum and aluminas. If this experience can assist you, your inquiry will be warmly welcomed. Contact your nearest Alcoa sales office, or write: Aluminum Company of America, 2027-D Alcoa Building, Pittsburgh 19, Pa.

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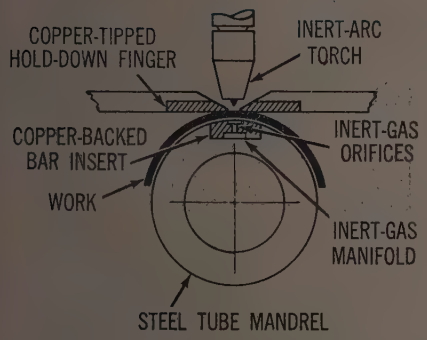

	Material Thickness (in.)			
	0.005-0.01	0.01-0.015	0.015-0.2	0.25
Backing Bar Groove Width (in.)	0.04	0.06	0.08	0.1
Backing Bar Groove Depth (in.)	0.015	0.02	0.025	0.03
Hold-Down Space (in.)	3/64	1/16	3/32	5/32

REFINED version of chill-shunt welding as used at AWEC.

BUTT welding two very thin sheets in a longitudinal welding positioner and welding machine.

Butt welding proves out for thin gages

The new technique of butt welding has brought the advantages of stronger and smoother weld seams and better post-weld formability to a wide variety of thin-gage aircraft and missile parts. Here is a report on the production setup needed for butt welding and on the various applications of this process.

by Gilbert C. Close, Technical Contributor

BUTT-WELDED wing and control surfaces leading edges have been used on some of our latest aircraft. These sections are stretch-formed to shape after butt welding and planishing. On such parts, the final smoothness of the planished weld is extremely useful.

The butt welding and planishing process has also been used on practically all joined airplane and missile sheet metal parts that can be welded while they are relatively flat. They include bulkheads, ducting, fuselage and skin sections, conically shaped nose sections, control surface parts, etc.

Butt-welded foils are relatively rare so far, but mark a very important development. For example, the foil-thin stainless steel blankets, or facing sheets used in building stainless honeycomb material are butt-welded together. The sheets are 0.005-0.01 in thick and produced in roll form about 24 in. wide.

According to the rolling mills, you can't roll this 17-7PH stainless alloy to a greater width. This makes it necessary to edge-join cut strips of the foil so as to produce honeycomb facing sheets of the proper size.

more on next page

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Tensile Tests of Thin-Gage Butt Welds*

	Ultimate Strength (psi)	Yield Strength (psi)	Elongation 2 In.	Elongation 0.5 In.	Fracture
		As Welded			
Nimonic 75 (PWA 673, 0.06-in. sheet)					
Maximum	110,638	60,857	28.5	24	plate
Minimum	110,212	58,227	28.1	22	plate
Average	110,466	59,550	28	24.3	plate
Type 316 Stainless (cres., annealed 0.039-in. sheet)					
Maximum	82,692	47,552	30	42	weld
Minimum	81,514	46,302	27.5	40	weld
Average	81,955	46,855	28.8	40.7	weld
		Roll-Planished			
Nimonic 75 (PWA 673, 0.06-in. sheet)					
Maximum	111,496	65,075	25	12	plate
Minimum	109,936	61,894	24	6	plate
Average	110,722	63,041	24.6	93	plate
Type 316 Stainless (cres., annealed 0.039-in. sheet)					
Maximum	85,467	50,522	50.5	32	sheet
Minimum	84,083	47,368	46	26	sheet
Average	84,913	48,835	48.1	28	sheet

*From tests of three specimens of each material for each condition. Neither all the maximum nor all the minimum values within any category necessarily were obtained from the same specimen. Causes of fracture in every case were the same for all three specimens in each category.

Longitudinal butt welding has proved ideal for this purpose. After planishing, the butt-welded seam is stronger than the base material. The smoothness of the weld seams is extremely useful when the honeycomb sandwich is used for an external part. Furthermore, the welded facing material may be post-weld-formed into the desired shape of the honeycomb structure after it has been brazed to the honeycomb core.

About 870 sq ft of the external airframe area of the Convair B-58 is of stainless honeycomb blanket material using butt-welded facing sheets. Butt-welded skin sections are also used on NAA's B-70 and X-15.

Thin-gage butt welding (covering thicknesses from 0.0001 in. up to the maximum conventionally joined by resistance lap welding) has become a specialty of Airline Welding & Engineering Co. (AWEC), Hawthorne, Calif. This company has designed a "longitudinal welding positioner and welding machine" and a "weld roll planisher" which together produce longitudinal fusion butt weld joints in thin materials.

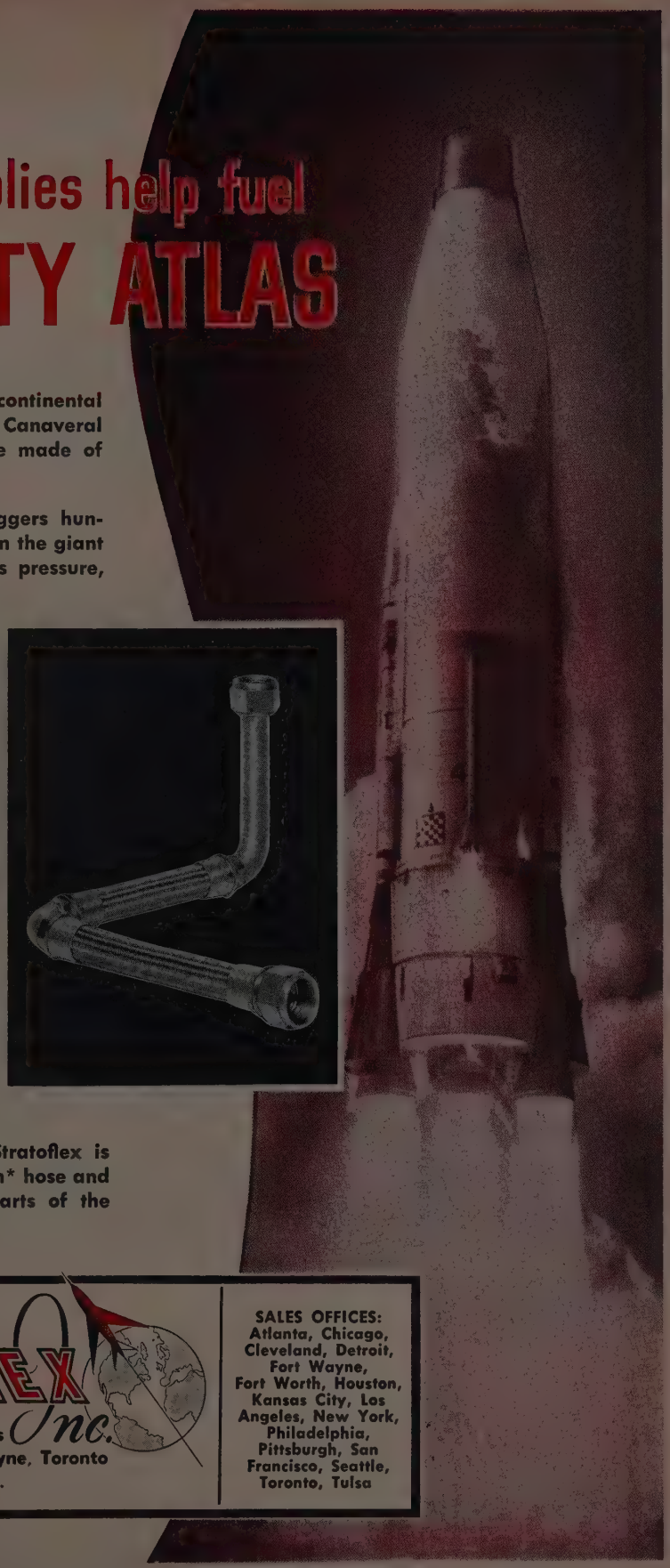
These joints are consistently stronger than the base metal on either side of the weld. Furthermore, the thickness of these weld joints approximates that of the basic metal on either side (+0.002-in.) and results in a clean aerodynamic surface. Both weight and material are saved over conventional resistance lap weld.

No filler material used on thinner gages

Basically, the longitudinal welding positioner grasps the two edges of the thin-gage material to be welded and holds them in alignment. The welding is done at a preadjusted speed by a traveling inert welding head that automatically passes along the seam. Inert gas shielded arc welding must be used with thin gages to avoid all oxidation. No filler material is used on the thinner gages—the edges are simply fused together into a weld

more on page 84

Stratoflex assemblies help fuel
THE MIGHTY ATLAS



Every time a Convair Atlas intercontinental ballistic missile lifts from its Cape Canaveral launching pad, fantastic demands are made of the fueling system and powerplant.

A touch of the blast-off button triggers hundreds of simultaneous chain reactions in the giant ICBM's fuel system. Under tremendous pressure, liquid oxygen is delicately and precisely force-mixed with a kerosene-like fuel and flashes through the lines as vapor to feed the fires burning in the combustion chamber. This blend, mix, fire sequence must commence in a split second and continue at tremendous speed if the launch is to be successful. Fuel line plumbing on the Atlas must be absolutely leakproof, immune to strong vibrations, and able to withstand continuous temperature variations.

Despite the infinite possibilities for human mistake and material malfunction, the Air Force, aided by Convair technicians, has successfully launched the Atlas ICBM time after time at Cape Canaveral. (In the spectacular December 18, 1958 firing, the 85-foot Atlas was placed in orbit around the earth.) Stratoflex is proud that its specially-designed Teflon* hose and metal tubing assemblies are vital parts of the Atlas fuel line system.

* A DuPont trademark

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SF1-9

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joint. This helps to keep the weld seam thickness the same as that of the base metal on either side.

Mounting the material to be welded in these machines is in itself a critical operation. A component sheet is placed in the machine and critically aligned along the welding mandrel. Then, pneumatically actuated, copper-tipped hold-down fingers clamp it firmly in place. The second component then is inserted from the other side of the mandrel and edge-butted tightly against the first sheet. A highly sensitive foot control, absolute contact of the two sheets is insured over the entire length of the joint.

The edges to be welded are pressed against each other so tightly by the hold down fingers that a microscopic amount of metal upset occurs. This compensates for any slight edge inaccuracies produced by the original shearing of the metal.

THIN-GAGE tapered cone section is butt-welded. It will later form the nose of a drop tank.

PLANISHING butt-welded seam in central section of fuel drop tank. Planishing rolls on newer machines swivel sideways so that long sheet welds can be fed between them.

The welding process is based on the "chill-shunt" theory. An obvious problem of thin-gage work is that there is so little base metal to absorb the heat generated by the welding process before it can do any harm. In chill-shunt welding, more metal is applied under pressure to the parent metal mass to increase the heat dissipation (see *Diagram*).

A copper backing bar and copper-tipped hold-down finger is used in AWEC's welding setup. Copper is the best metal for conducting heat away from the weld area. It also has a relatively high melting point of 1981 deg F and its softness reduces the danger of scratching the material during handling.

Superior butt welds are obtained consistently with the longitudinal welding machine alone. The welds are accurate, and heat effects on the base metal are held to a min-

more on page 86

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liquid temperature sensing thermostats

Smallest probes on the market for handling 3 watts at 30 VDC—only ⅜" insertion required for proper sensing. 1½" to 4¾" overall lengths.

Safe in explosive atmospheres or highly combustible liquids. Tamper-proof sealed-in contacts.

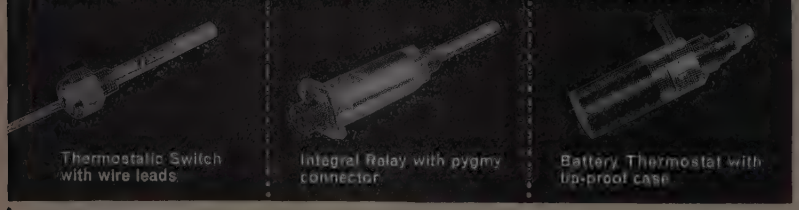
Mercury in column makes, breaks contacts. No moving mechanical parts to wear out or mal-function. Only simple circuits required.

Temperature set point doesn't drift . . . stays reliable throughout thermostat life.

Unaffected by altitude, moisture, vibration, 100 G shocks!

Actual size 3"
Thermostatic switch with MS connector

THERE'S A VĀP AIR MERC FOR EVERY REQUIREMENT



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The twin-jet T-38 –America's first supersonic trainer–aptly demonstrates Norair's capability in systems management. Now in production under USAF contract, the T-38 Talon is the first member of a Northrop-conceived family of lightweight, low-cost space age aircraft.

Soon to follow: a supersonic counterair fighter, the N-156F – first weapon system designed in America for the specific tactical and economic requirements of those free allied nations most vulnerable to enemy attack.

Other important systems management achievements include the USAF Snark SM-62A and the F-89 Scorpion. Norair management of the Snark program produced the free world's first operational intercontinental guided missile – delivered on time and at minimum cost.

In producing America's first nuclear-armed interceptor, Norair's weapon system management of the F-89 was marked by on-time delivery of more than 1,000 units throughout the program's life, and by a significant dollar underrun. A full ten years after its first flight, the Scorpion is still the USAF's most heavily armed interceptor – and a uniquely stable platform for air-launch of atomic rockets.

Norair's cost-proved record of effective management, integrated facilities, and available resources combine to demonstrate outstanding capability as a prime systems contractor.

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TEFLON* NEWS FROM R/M

Now, larger sheets . . . color-striped thin-wall tubing

Easy identification in multiple tubing installations is made possible by R/M color-striped thin-wall "Teflon" tubing. Tubing is also available without striping.

Larger sheets. R/M now makes 1/32-in.-thick Teflon in 36 x 36 in. sheets. Other "Teflon" products include tape, tubes, rods, hose and bondable "Teflon."

Here are two big features added to Raybestos-Manhattan's extensive line of "Teflon" products for use in aircraft, missile and rocket components. First, 1/32-in.-thick "Teflon" can now be supplied in 36 x 36 in. sheets . . . other thicknesses available in sheets up to 48 x 48 in. And second, to permit the ready identification of lines in multiple installations—R/M thin-wall "Teflon" tubing is now available with a permanent identifying stripe in a range of colors.

These additions reflect R/M's continuing program to extend applications for "Teflon." This program — begun soon after the introduction of "Teflon"—has provided R/M engineers with a vast fund of know-how . . . where to apply "Teflon," how to design with it, and how to fabricate it. Let R/M's "Teflon" know-how work for you. Contact your nearest R/M district office for friendly, competent assistance. Or write for literature to Plastic Products Division, Manheim, Pa.

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imum. When these thin-gage butt welds are pulled to destruction "as welded," failure in most cases will occur outside the weld.

For aircraft and missile structures, AWEC uses its weld roll planishing machine to further condition its thin-gage butt welds.

The planisher has two heavy rollers that are hydraulically forced together at a preadjusted pressure. The weld seam is fed between these rollers, and their pressure of up to 100,000 psi cold-work the "as cast" weld metal. This refines the metal grain and increases its ultimate and yield strengths. At the same time, it thins out the weld seam somewhat and smooths any surface irregularities left by the welding torch.

After a thin-gage butt weld has been properly planished, the weld seam shows up only as a slight discoloration along the weld. The weld seam itself is just as smooth as the base metal on either side and fares perfectly with it. On all thin-gage alloys welded so far, planishing has increased the strength of the weld beyond that of the base metal (see *Table*).

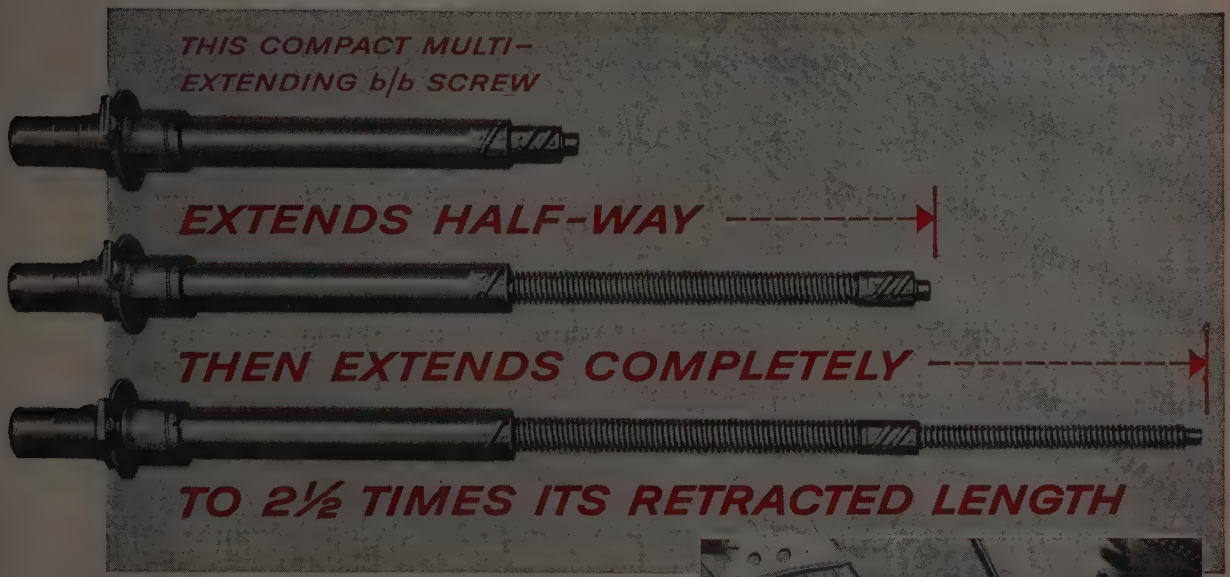
AWEC president B. R. Russell, says that production butt welding has been done successfully on materials as thin as 0.003 in. Experimental work proves that even thinner gages may be butt-welded. All conventionally weldable materials as well as all types of stainless steel, titanium, Inconel, copper, and beryllium copper have been butt-welded successfully in these very thin gages.

In explaining the advantages of butt welds over lap welds, Russell points out that lap weld specimens tested in tensile almost always break in the weld. There isn't any known way of improving their strength, he says.

Butt welds have proved far more resistant to vibratory stresses than lap welds. If a failure does start in a butt weld, it is—in contrast to a lap weld failure—easy to spot and repair.

The AWEC positioner and welding machine is just as good for welding longitudinal seams in circular or conical parts as it is for welding two flat sheets together. The curved part first is sheared and rough-formed. Then it is slipped over the welding mandrel, positioned, and welded. This is followed by planishing. Write in No. 53 on Reader-Service Card for more information.—End

FAR-REACHING EXTENSION FROM LIMITED ACTUATOR SPACE



Now Saginaw supplies the answer to your most difficult actuator space problems with the Multi-Extending Saginaw Screw! Utilizing Saginaw's time-proved *recirculating ball* principle in multiple telescoping sections, the Multi-Extending b/b Screw conquers actuator space obstacles designers have been seeking to overcome for years! Here's why:

1. **UNIT EXTENDS** in a ratio of 2.5 to 1, providing maximum extension 2½ times the length of the retracted screw.
2. **FAR GREATER LOAD CAPACITY** than any other telescoping device in its class.
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4. **PRECISE, DEPENDABLE POSITIONING** and control within thousandths of an inch.

• OVER 90% EFFICIENCY • REQUIRES UP TO 4/5 LESS TORQUE than acme screws • LESS DRAIN on power supply • CONSERVES SPACE AND WEIGHT • OPERATES DEPENDABLY at extreme temperatures • PERFECT FUNCTIONING with only initial lubrication

USED ON THE COUNTRY'S MOST MODERN AIRCRAFT—Multi-Extending b/b Screw wing flap actuators being installed on the new Lockheed Electra.

The Saginaw Multi-Extending Screw is also used to actuate speed brakes, afterburners, variable air inlets, canopies and similar critical components on today's newest aircraft.

Send today for the new 1959 engineering data book on Saginaw b/b Screws and Splines...or see our section in Sweet's Product Design File.

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ball bearing Screw

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These vehicles have the advantages of: • All Wheel Traction • Low Floatation Pressures • Proven Cargo Stability • Greater Load Capacity

And most of these vehicles can be made of *standard axles and transfer cases* which are available through the world-wide military supply system. These same parts can be assembled in combinations to make driving units for *four, six or eight wheel vehicles.*

Today Rockwell-Standard leads the way for the industry with Timken-Detroit® steering axles, drive axles, tandem axles, trailer axles and transfer cases; and Hydra-Drives® torque converters and power shift transmissions.

Rockwell's 50 years experience in *designing, engineering and manufacturing,* plus their *advanced research and testing facilities* insures you of the utmost in dependable, highest quality products. Look first to Rockwell-Standard for the best in power transmission components.

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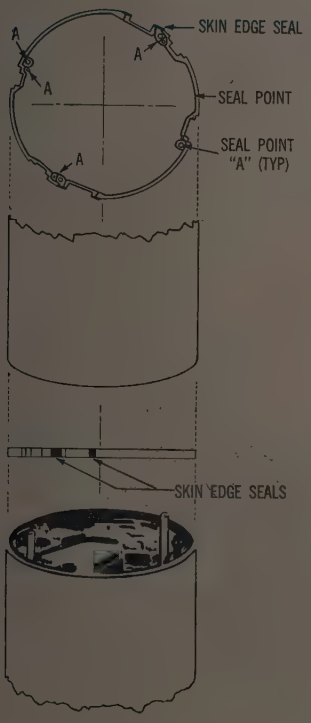
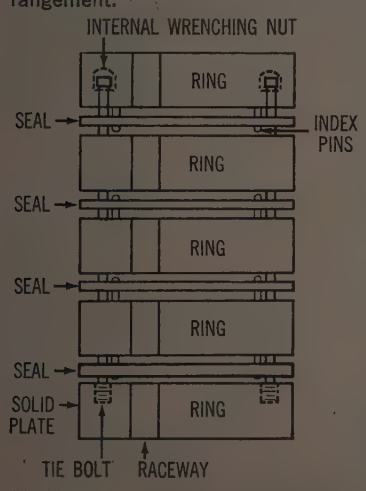


FIGURE 1: Key sealing points of single sealing device, skin edge seals and lead-throughs, and seal gland configuration.

FIGURE 2: Schematic of Tartar airframe shows integrated sealing arrangement.



Integrated seals simplify Tartar design

Achieving near-perfect sealing has become one of the most important parts of missile air-frame design. Here's how this problem was solved on one of the newest missiles, the Navy's surface-to-air Tartar.

by Wendel Haas, Senior Design Engineer,
Pomona Div., Convair*

BECAUSE of the extreme performance demanded of today's missiles, these must have near-perfect sealing. Often this requirement is referred to as "no-leakage" sealing. However, this term actually seems to cover a great variance in the amount of allowable leakage, depending usually on who's using the phrase.

On the Tartar project at Convair-Pomona, the sealing committee instituted a design and test study that resulted in a mechanical seal that not only serves as a structural part, but also meets the most exacting requirements of Mil-S-8484 (USAF) on hermetic sealing. It provides for sectional sealing the missile from bulkhead to bulkhead rather than the customary individual sealing of each of the critical components (*Fig. 3*).

Sectional sealing reduces weight and gives a much cleaner and more simplified overall design. It also makes for more economical production.

Generally it's considered desirable to use inert gases throughout the entire body section of a missile such as the Tartar to pressurize an entire electronic assembly. The near-perfect seal obtained in our program is well suited to such pressurization. Integrated sealing also allows the use of less expensive components and harnessing, thanks to the absence of any corona effect in high altitude operation.

In our studies, the project group could find no mechanical specification that quite covered the requirements. As usual on missiles, it was necessary to make internal components and devices accessible for adjustment, repairs, etc. This ruled out such methods as welding or other "solid" or "fusion" sealing.

Since the seal had to be "breakable", a mechanical seal was the only answer. Ordinary standards for such seals couldn't apply. The group decided to use parts of Mil-S-8484 for qualification, though this spec had been set up for electronic enclosures with hermetic sealing.

This spec has four grades, all based on a pressure differential of one atmosphere, whose maximum leakage rates per year and inch of seal are, respectively, one (A), 99

more on next page

*Pomona Div., Convair (Div. of General Dynamics Corp., 1675 W. 5th St., Pomona, Calif.)

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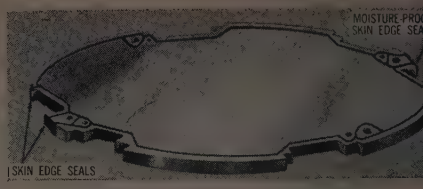

FIGURE 2: Sealing arrangement forms integral part of Tartar bulkhead as shown here. Sealing design includes both single-piece interior seal and edge seals that are compressed against the skin.

(B), 9999 (C), and over 10,000 (D) standard cubic centimeters of air. Only the first two grades were acceptable for the Tartar.

Grade A is defined as "a seal that is accomplished by the fusion of metallic and/or ceramic materials. This will include the fusion of metals by welding, brazing or soldering; the fusion of ceramic materials into a metallic support." Grade B is "a seal that is accomplished by the fusion, vulcanizing, or adhesion by use of chemical and/or mechanical process of any other material such as thermosetting plastics or elastomers to the metallic case, structure or assembly." Neither definition refers to mechanical seals; nevertheless the allowable leakage rates could be adapted to our needs.

Five critical seals are used

There are five critical seals on the Tartar, all structurally integrated. One of these actually forms a bulkhead. It features several lead-through sealing points on the enclosed portion of the bulkhead as well as sealing against the skin of the missile (*Fig. 2*).

This seal is an adaptation of the Gask-O-Seal, developed by Parker Seal Co., of Los Angeles. It seals on both sides as well as on the edges at eight different points, yet is all in one piece (*Fig. 1*).

Normally, this seal seals only on one plane. By adapting it as a structural part (i.e., a bulkhead to separate compartments), we could provide enough thickness for the metal retainer so that seal glands could be molded on the edges to seal against the skin at points at which lead-throughs are necessary.

Hermetic sealing of compartments is vital to reliable perform-

more on page 92

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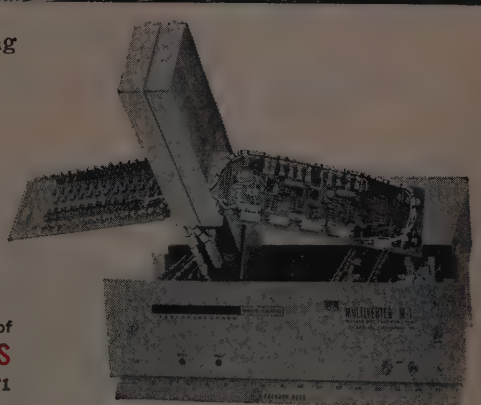

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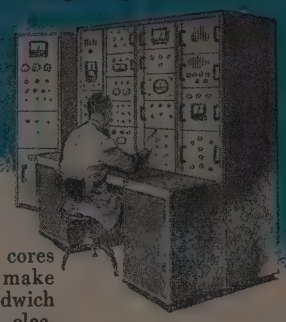

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ance of the missile. Spec A of Mil-S-8484 was the only acceptable qualification. All seals were subjected to the testing procedures outlined in this spec (including cycling, shock, vibration, moisture resistance, pressure, etc.).

Largely because of the very limited area of the seal gland that is exposed to attack by fluids (air, hydraulic oils, salt water), moisture penetration was so low as to be not recordable on existing measuring instruments. Where a degree of leakage was recorded, it was estimated to be not much more than that which would occur through molecular permeation of the metals.

The seals permit rougher surface finish

Our seal design allowed us to use lighter flanges and smaller and fewer fasteners, thanks to a lower fastening torque requirement. In addition, surface finish of the seal and flange required only 58 RMS. Although it was found that even better results might be obtained with it, a finer finish wasn't necessary. The degree of surface finish was mainly limited by the angle of "scratches" with respect to the seal. Scratches parallel to the seam allowed a much rougher finish while still permitting adequate sealing.

The Tartar seal, being one integral piece, is easily replaced in the field and is re-usable (under ordinary circumstances). By providing proven, leakproof sealing, it may reduce environmental qualification requirements for internal components, which could materially decrease costs and lead to easier assembly and maintenance. It could also simplify production for instance, by eliminating dipping and other processes now needed to avoid arcing.—End

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This is the cabin interior of Lockheed's test Electra airplane. The engineer adjusts control panel for oscillographic recorder at lower right

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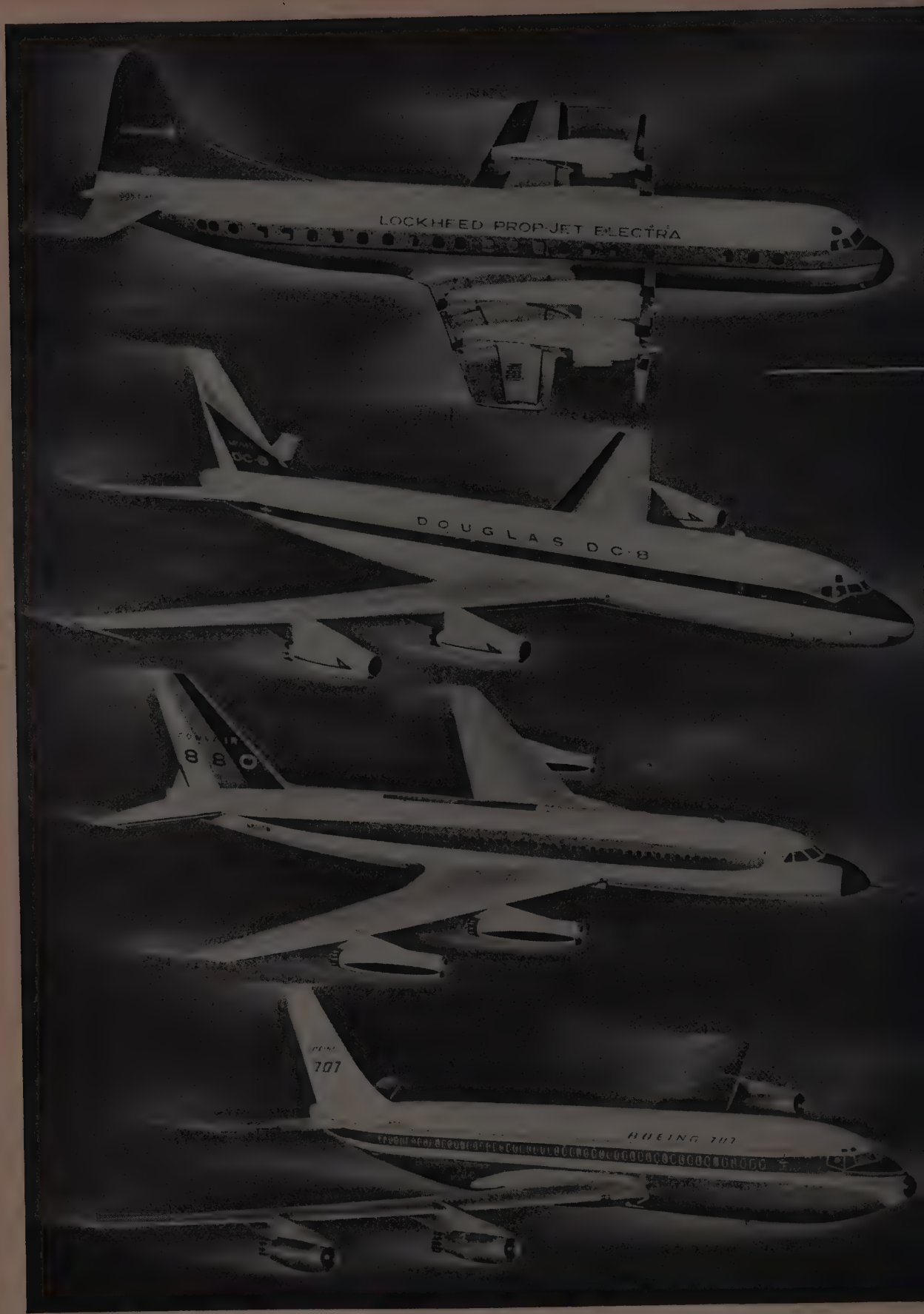
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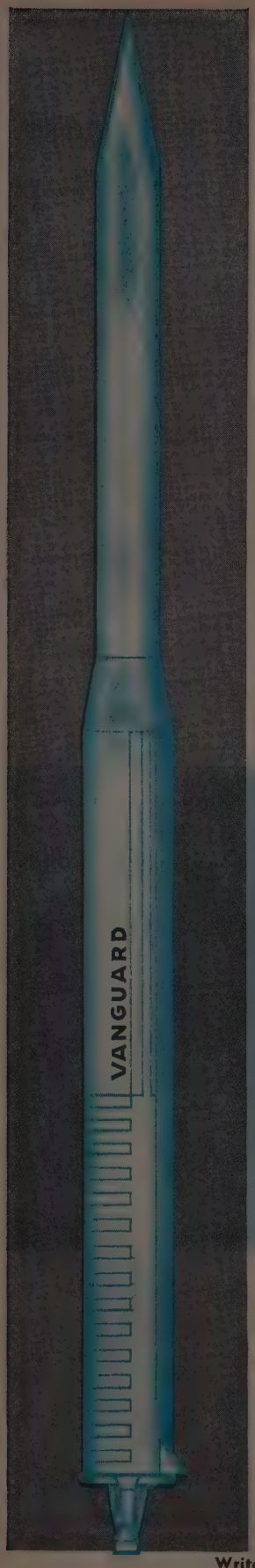

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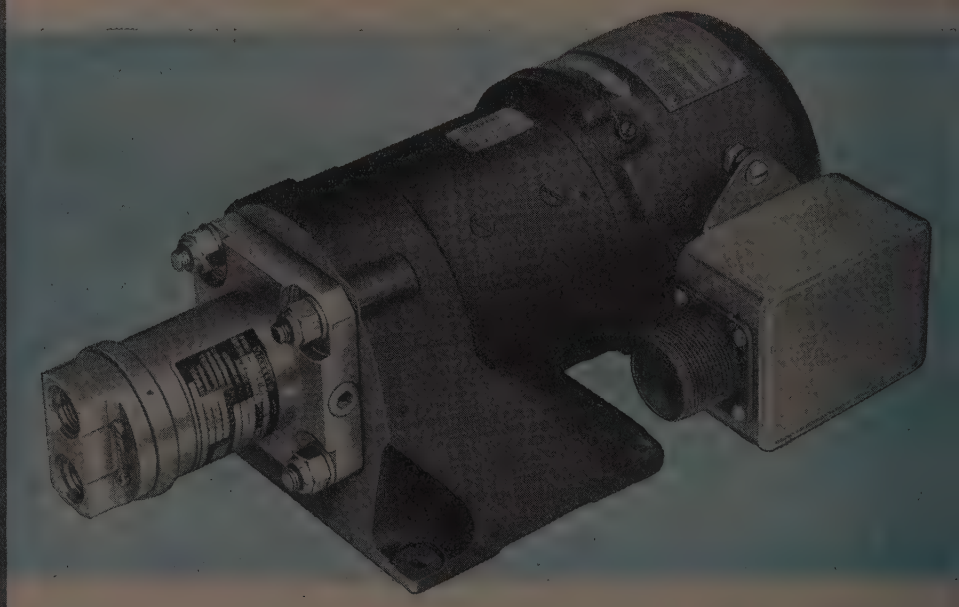

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FIGURE 1: Typical coated molybdenum specimens for NBS tests (left). Top specimen hasn't been heated; bottom two failed after 300 hours at 1100 deg F, the difference between them showing the variation in samples prepared under identical conditions. Right: Diffusion bar of molybdenum after 600 hours at 1100 deg C shows 1-2 per cent of the metal diffused into outer layers. The plating is two mils chromium and 14 mils nickel.

Molybdenum coating

stands up at 2000 deg F

The oxidation problem of molybdenum at high temperatures has occupied the attention of many researchers in recent years. A new composite chromium-nickel coating, developed by National Bureau of Standards, may now pave the way for wider use of this metal.

A COMPOSITE electrodeposited coating developed by the National Bureau of Standards, Washington 25, D. C., holds great promise of solving the high temperature problem of molybdenum in turbine blades and similar applications.

The coating, which is nickel over chromium, has prevented oxidation for over 1000 hours at 980 deg C (1792 deg F) and over 300 hours at 1100 deg C (2012 deg F). *Figure 3* shows the effect of nickel thickness on the oxidation life of coated specimens. Studies of this coating, researchers report, show that, properly applied, it meets the requirements for molybdenum protection—it is not only oxidation-resistant, but also non-porous and ductile.

The first step in the plating procedure is to etch the molybdenum with a 1:1 solution of concentrated sulfuric and phosphoric acids. A one-mil chromium deposit is electroplated onto the molybdenum at 85 deg C and 120 amp/dm^2. The newly plated surface is again etched with a 1:1 hydrochloric acid, given a nickel strike, and plated with seven mils of nickel. For this purpose, NBS states, nickel deposited from a Watts-type bath at 2-5 amp/dm^2 is superior to deposits from an all-chloride bath.

Several types of durability experiments were conducted with the coated samples. The completed specimens were bent until fractured to test the bond between coating and molybdenum. Excellent plating adhesion properties were shown here, since the break was usually within the molybdenum itself and not within the electrodeposited layers. To a large extent, NBS notes, the soundness of the deposit determines the effectiveness of the protection.

Coated specimens were exposed

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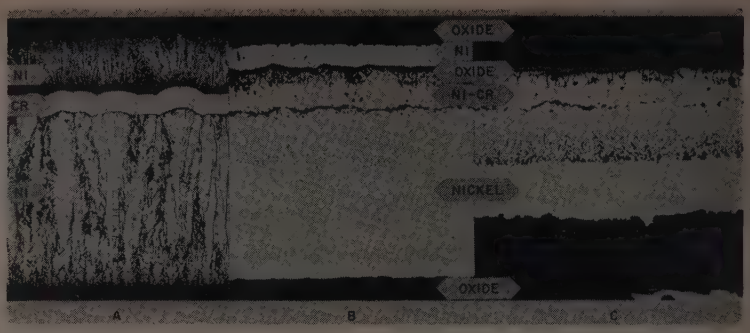

FIGURE 2: Cross-section of coated molybdenum specimens is shown in NBS micrographs: A—initial sample with coating; B and C—extent of oxidation at 1100 deg C after 70 hours and 300 hours, respectively.

to air at 1100 deg C until the coatings were perforated or until a white smoke of molybdic oxide appeared (*Fig. 1*). At this temperature, the coating withstood oxidation for an average of 300 hours, but at 1200 deg C, oxidation occurred much faster. Preheating of the samples in an inert atmosphere decreased the oxidation life of the coatings.

A series of coated specimens, that had been subjected to different periods of air oxidation at 1100 deg C, were run through metallurgical tests (*Fig. 2*). These indicated three underlying causes of failure: subsurface oxidation, grain-boundary oxidation, and edge separation.

The subsurface oxide, researchers state, is due to reaction with atmospheric oxygen and not with oxygen trapped in the coating. This

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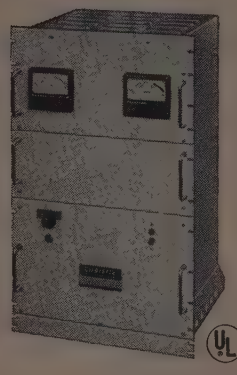

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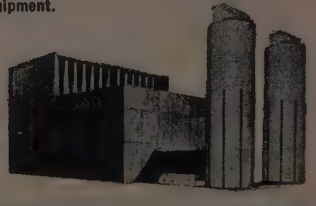

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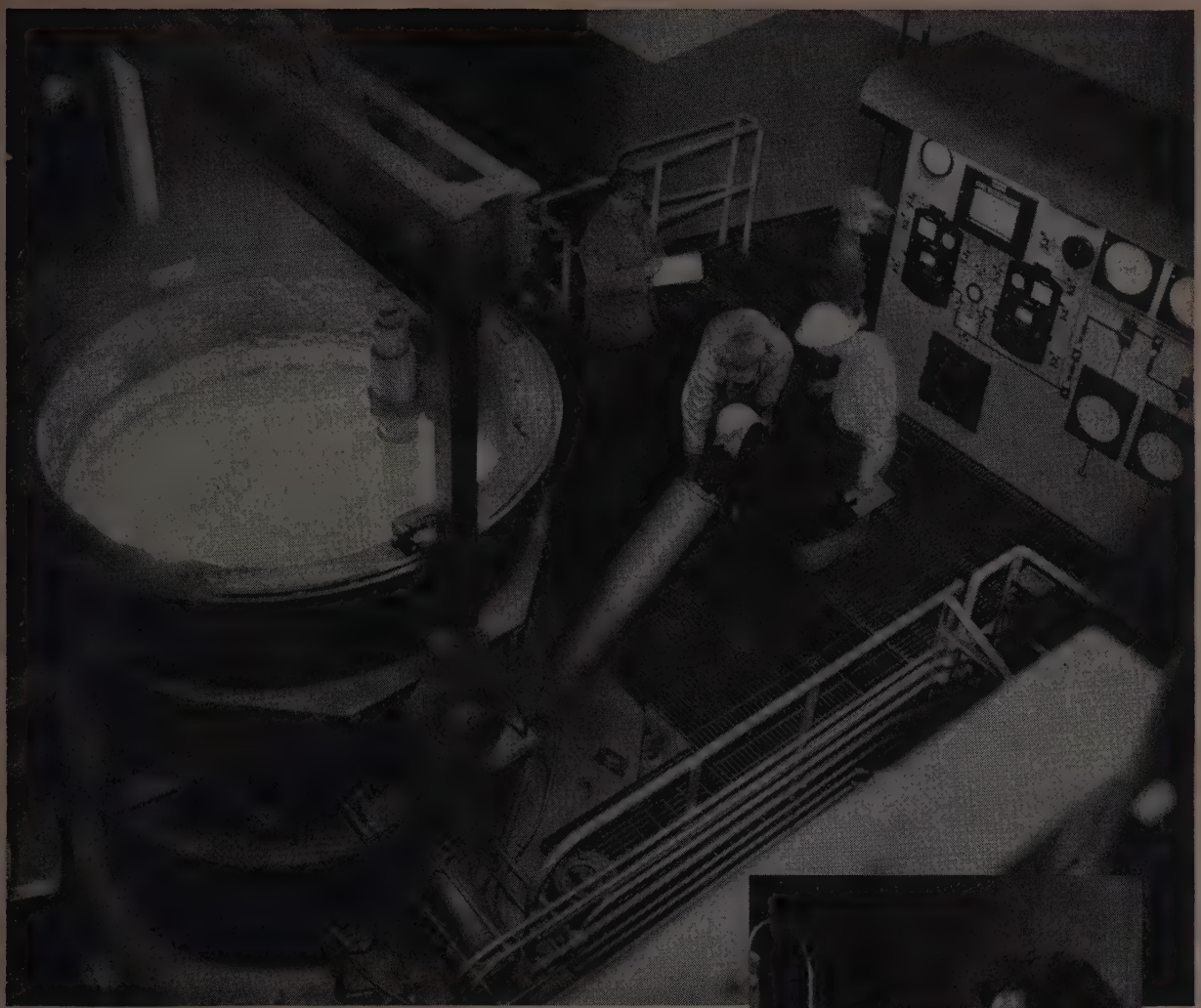

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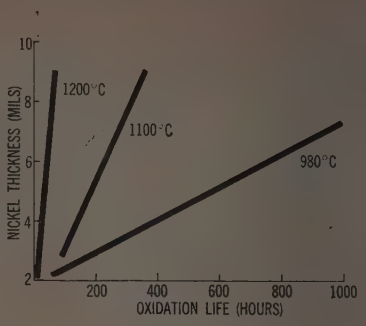


FIGURE 3: Increasing thickness of nickel in new NBS molybdenum coatings, curves show, increases metal's oxidation life. For about seven mils thickness, life of over 1000 hours at 980 deg C was obtained.

was proved by the fact that the oxide wasn't observed in samples heated in a helium atmosphere. Apparently, says NBS, the subsurface oxide layer is caused by the diffusion of atmospheric oxygen passing through the nickel coating and reacts with the nickel-chromium alloy underneath.

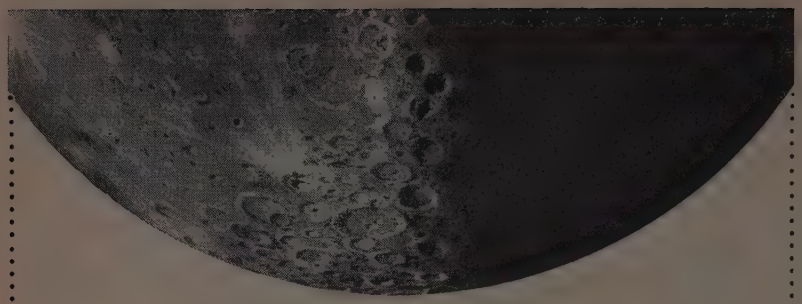
The boundaries of the metal crystals are more vulnerable to oxygen attack. Grain-boundary oxidation directly follows the boundary of the grains.

Edge separation occurs within the chromium-nickel diffusion layer when a sample is alternately heated and cooled several times. This type of defect, which actually produces a gap within the layers, is being further studied at NBS.

A study was also made of interdiffusion of molybdenum, chromium, and nickel. For this test, a bar of molybdenum was plated with two mils of chromium and 14 mils of nickel and then heated in hydrogen. After 600 hours at 1100 deg C, 1-2 per cent of the molybdenum had diffused to the surface (*Fig. 1*).

Although this metal could be detected through 10 mils of nickel, no structural changes were noted. It was concluded that small amounts of the molybdenum that diffuse into the surface don't appreciably affect the grain structure of the coating.

In another test, electroformed nickel (instead of molybdenum) was coated with chromium and nickel and then oxidized. The same three defects occurred as with the coated molybdenum, indicating the molybdenum itself isn't directly involved in these major sources of failure.—**IS**



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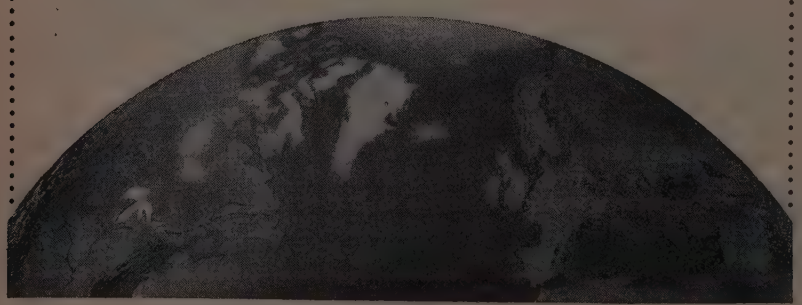
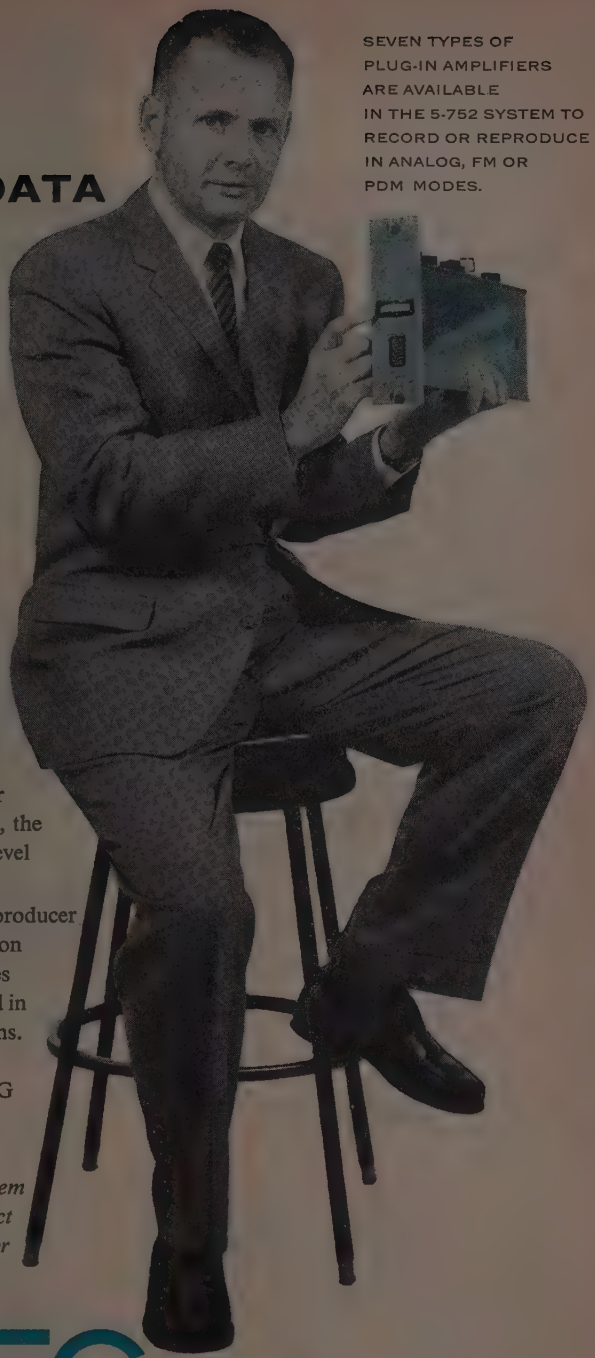


Check Employment Inquiry Form on Page 181

Save time . . . insure accuracy

MONITOR YOUR TAPE DATA

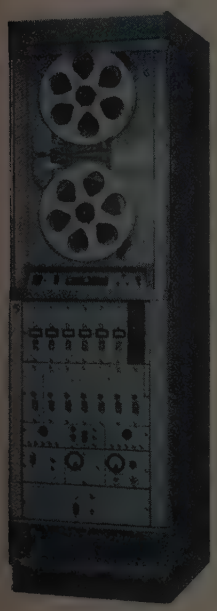
with integrated amplifier meters



SEVEN TYPES OF PLUG-IN AMPLIFIERS ARE AVAILABLE IN THE 5-752 SYSTEM TO RECORD OR REPRODUCE IN ANALOG, FM OR PDM MODES.

CEC's new record and reproduce amplifier meters mount *directly* on individual Analog or FM amplifiers of the standard 5-752 Magnetic-Tape Recorder/Reproducer System . . . to save time and assure accuracy. On *record* amplifiers, the meters allow continuous monitoring of incoming signals. On *reproduce* amplifiers they are used to monitor output signals and to provide positive indication that test data are being recorded on tape.

Mounting of the meters directly on the amplifier panels significantly reduces the possibility of stray pickup being mixed with signals and also eliminates the confusion in channel identification that often occurs when meters are remotely located. The monitor meters do not adversely affect the recorded signals or normal operation of the amplifiers.



By providing a means of locally adjusting signal and bias levels, the meters are invaluable when setting up the 5-752 prior to a test run. On Analog record amplifiers, the units can be used to monitor bias signal level by means of a front panel selector switch.

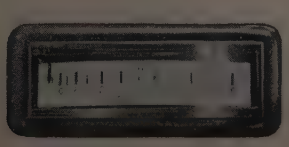
CEC's 5-752 Magnetic-Tape Recorder/Reproducer System provides up to 14 tracks of precision data recording and playback of frequencies from d-c to 100 kc. The 5-752 is widely used in industrial, medical and military applications. Among its features are all-metal-surface magnetic head stacks . . . six standard IRIG tape speeds . . . lowest cumulative flutter characteristics.

For complete information on the 5-752 system and CEC Amplifier Monitor Meters, contact your nearest CEC sales and service office or write for Bulletin CEC 1576-X35.

DataTape Division CEC

CONSOLIDATED ELECTRODYNAMICS *300 N. Sierra Madre Villa, Pasadena, Calif.*

FOR EMPLOYMENT OPPORTUNITIES WITH THIS PROGRESSIVE COMPANY, WRITE DIRECTOR OF PERSONNEL



METERS ARE AVAILABLE ON CEC ANALOG OR FM RECORD AND REPRODUCE AMPLIFIERS AS FACTORY INSTALLED OPTIONAL EXTRAS, OR THEY MAY BE ORDERED IN KIT FORM FOR INSTALLATION BY THE USER. KITS INCLUDE METER, NEW AMPLIFIER FRONT PANEL AND FULL INSTALLATION INSTRUCTIONS.

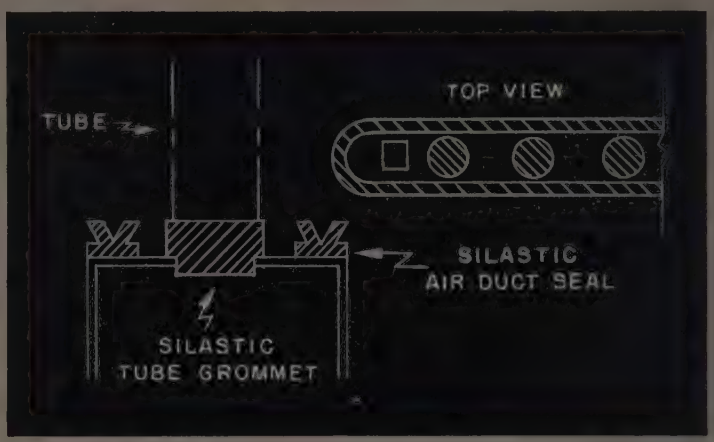
Write in No. 29 on Reader Service Card at start of Product Preview Section

The PLANE

America's newest production bomber, the Convair B58 Hustler. This delta-wing jet employs an area-ruled fuselage for supersonic regime efficiency, and has reportedly been flown in excess of Mach 2 at 50,000 feet. Engines are four J 79's, in pods below the wings.

The PROBLEM

Sealing and cushioning vacuum tubes in cooling air ducts for the B58 Fire Control System, designed and produced by The Emerson Electric Manufacturing Company. Difficulties involved include heat —the sub-miniature tubes operate as high as 350 F— and severe cold when the units are inactive during flight. Protective material must stay resilient despite these extremes.



The PART

....SILASTIC

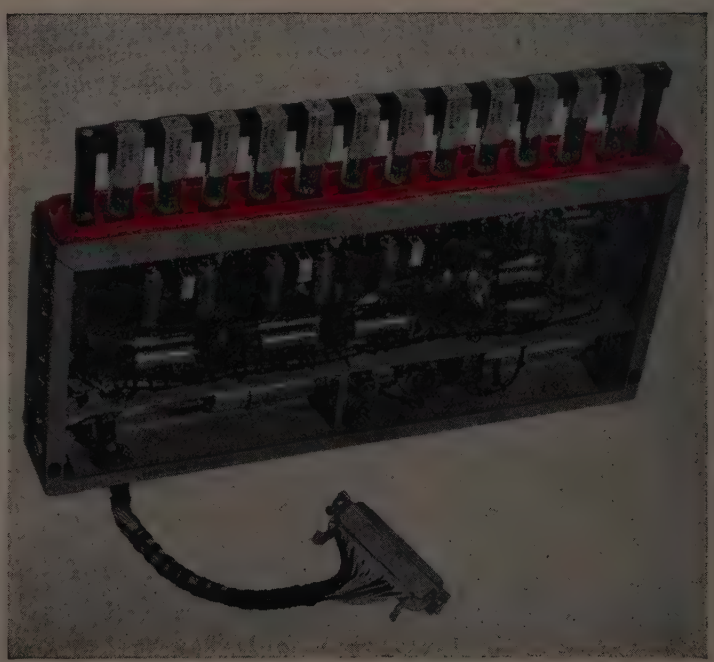
SILICONE RUBBER

Tubes and other electronic equipment in the B 58 are cushioned by molded parts of Silastic®, the Dow Corning silicone rubber. Silastic stays rubbery, has excellent electrical properties.

TYPICAL PROPERTIES OF SILASTIC MOLDED PARTS

Temperature range, °F	—130 to 500
Tensile strength, psi	600 to 1400
Elongation, %	150 to 500
Electric strength, volts/mil	300 to 500

For further information write Dept. 0716.



first in silicones

Dow Corning
CORPORATION
MIDLAND, MICHIGAN

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LOX CHARGE TANK (left) supplies vaporizer, which changes oxygen to gaseous state and returns GOX through the top of the charge tank. Flow meter is calibrated from 10,000-lb scale on which the charge tank rests. Right: High pressure helium test station is another part of the Whittaker facility for environmental testing.

GOX laboratory

simulates combined environments

With ever-increasing demands for reliability, specs naturally call for more rigorous qualification tests for cryogenic valves and components. To meet these demands, Whittaker Controls set up its own cryogenic test facility, which is also available for general industry use.

ONE of the most complete environmental test labs for such missile components as cryogenic dump valves has recently begun operations at Chatsworth, Calif. The lab eventually will have facilities for testing with gaseous oxygen (GOX), liquid oxygen (LOX), high pressure helium and nitrogen, etc.

The lab was set up by Whittaker Controls Div., Telecomputing Corp., 915 N. Citrus Ave., Los Angeles 38, Calif., when company engineers needed new types of facilities to test valve designs under extreme environmental conditions. Its services are also offered to other manufacturers.

Currently in operation is a GOX test lab that can flow from 1-33 pps of GOX at pressures of 84.7 psi. The temperature of the GOX at the units under test presently can be controlled from —220 to —290 deg F; with relatively minor changes, this could be lowered to —300 deg F. In the future, by using liquid nitrogen or helium exchangers, extreme cryogenic temperatures could be achieved.

The basic GOX facility consists of a 5500-lb LOX storage tank and a liquid vaporizer system (*Schematic*). A unique feature is that ambient air is used for vaporization. The blower will flow 72,000 cfm with an exchange rate as high as 20×10^6 btu hr. One major advantage of this arrangement, company engineers told SPACE/AERONAUTICS, is that it eliminates the risks of gas-fired or electric heat exchanger systems, which can be blown up by a hole in an oxygen tube. A supplementary 6000-lb LOX tank and a

more on page 106

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Investigate TITANIUM!

As missiles extend their range and speed, weight-saving becomes an increasingly critical design consideration.

Take rocket cases, for example. In the third stage—where the exchange ratio is very high—it is estimated that every pound of weight saved adds 10 miles' extra range.

This is where titanium and its alloys can give designers, and missiles, a big boost. For titanium can *cut weight up to 57% over alloy steels.* And new titanium alloys produced by Mallory-Sharon now provide *welded* strength/weight ratios close to 1,000,000!

For rocket cases as well as other missile components—cryogenic vessels, pneumatic and hydraulic lines, forged fittings and many other production parts—investigate titanium! As a leader in titanium and special metals technology, our Service Engineering group is ready to provide you with technical information, application assistance, or help on fabrication problems.

Rocket cases

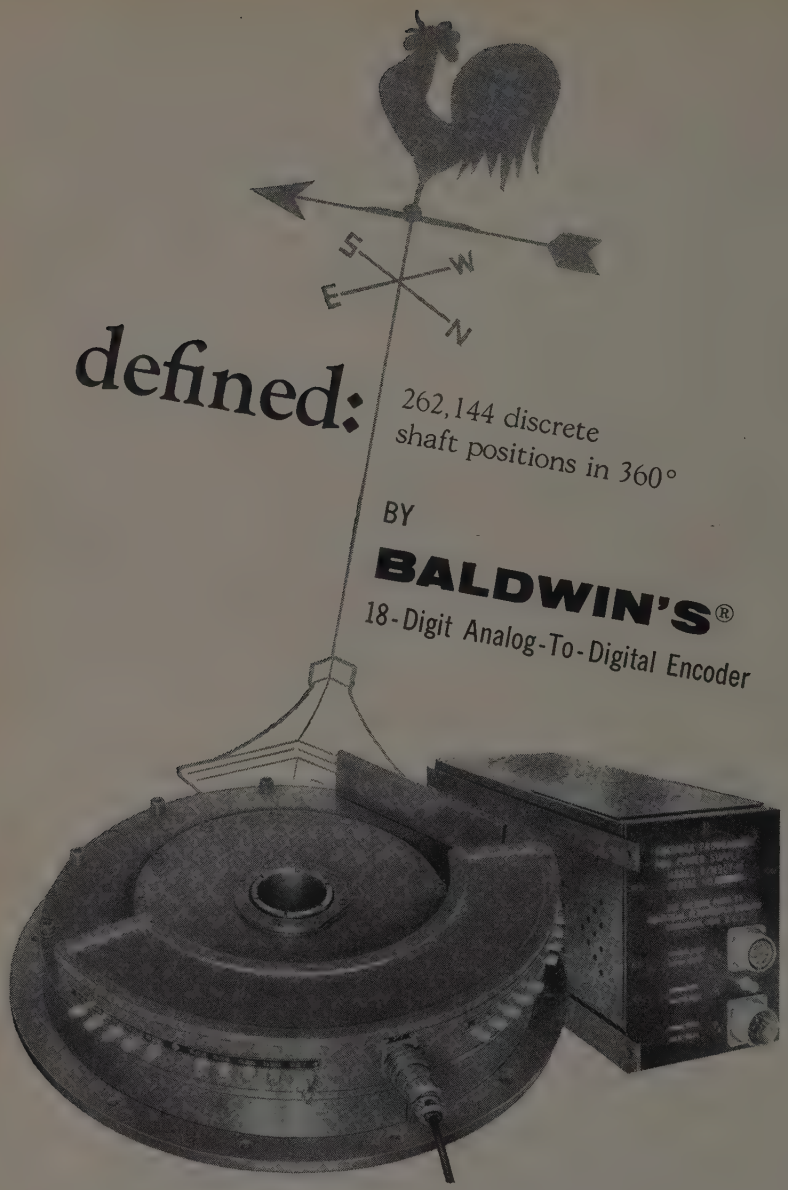
Cryogenic vessels

Production parts

MALLORY SHARON

MALLORY-SHARON METALS CORPORATION · NILES, OHIO

Integrated producer of Titanium · Zirconium · Special Metals



defined: 262,144 discrete shaft positions in 360°

BY

BALDWIN'S®

18-Digit Analog-To-Digital Encoder

This complete, ready-to-use package . . . Baldwin *extreme high-precision* 18-Digit Encoder and Programmer-Power Supply . . . is now available for very high accuracy applications involving translation of angular shaft position into digitized components. *Encoder accuracy is* ± 1 *part in* 262,144. Code output is reflected binary. Programmer-Power Supply provides proper voltages and trigger pulse for the encoder amplifiers and flash lamp.

Also available are three sizes of the Baldwin 13-Digit Encoder and two models of the Baldwin 16-Digit Encoder. Encoders with decimal, trigonometric functions and other nonlinear codes can be supplied. Write for full details and descriptive literature.

See Baldwin Encoders displayed at the John A. Green Co. exhibit, Southwestern IRE Show.

INDUSTRIAL PRODUCTS DIVISION

the Baldwin piano co.

1809 GILBERT AVE., CINCINNATI 2, OHIO

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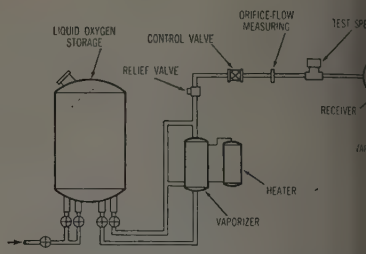


GOX test facility set up by Whittaker Controls.

2500-lb liquid nitrogen tank have also been installed.

The LOX charge tank for the vaporizer has flexible joints and rests on a 10,000-lb balance used to help calibrate the system's inertial mass flow meter. The scale is claimed to be sensitive to one pound in 10,000.

The scale is originally set to a value a little below that of the LOX to be used, and the run is started. When enough LOX has been used to achieve a balance, a switching device automatically starts a timer going in the blockhouse and the mass flow meter begins recording data on both a preset and a regular digital counter.

As the run proceeds, Bureau of Standards tare weights, previously supported by pneumatic cylinders and equal to the LOX to be used, are released to hang from the tank and force the scale down. As LOX is used up, the tank moves up. When the predetermined balance is reached, timer and mass flow meter are switched off. The weight of the LOX that has been used is plotted against time and compared with the mass flow meter data.

A "combined environments" chamber is used

The units under test are housed in a "combined environments" test chamber. This unit is made of six sides mitered together and consists entirely of inorganic materials (mostly glass). The sides are held together by ceramic pins with studs.

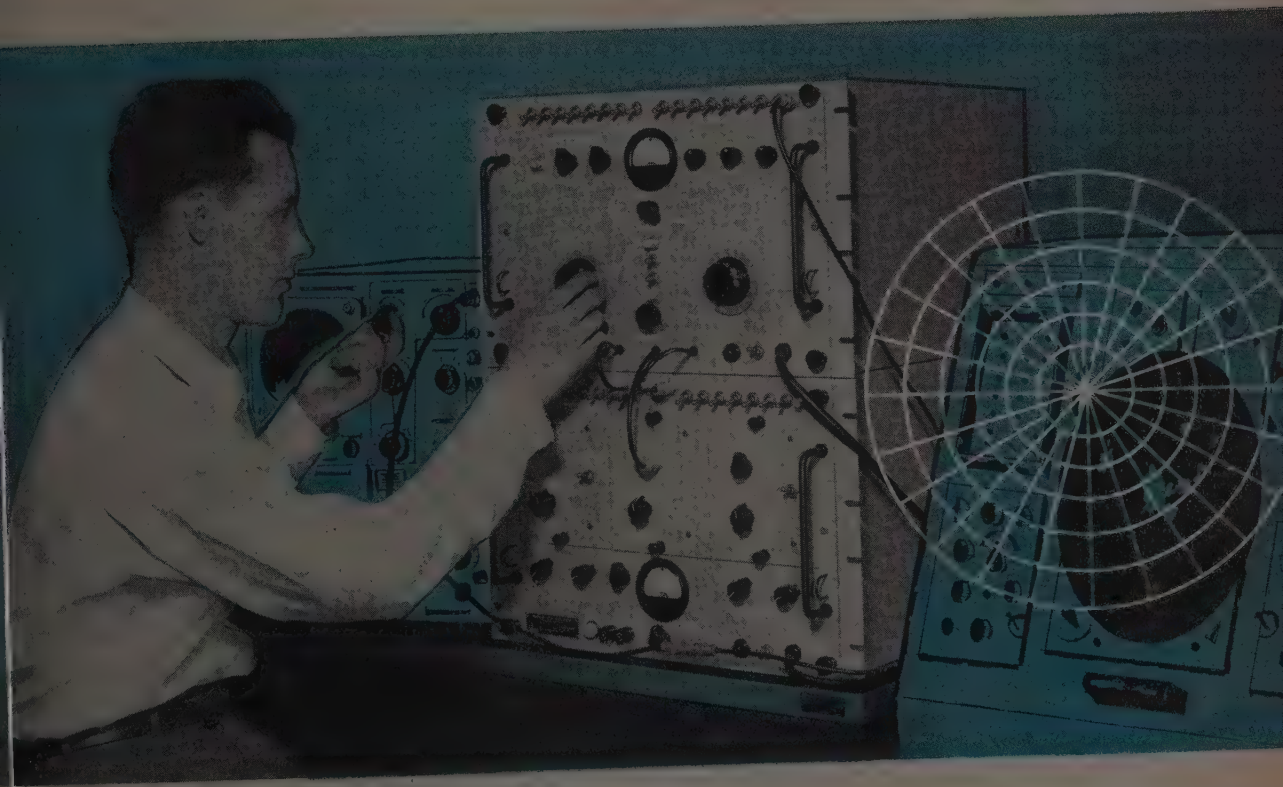
The 64-cu ft chamber can be raised, and a shaker can be placed underneath it. Internal temperature can be varied from —300 to + 400 deg F in 15 minutes. While GOX is flowed at rates up to 35 pps, humidity, rain, frost, and vi-

more on page 110

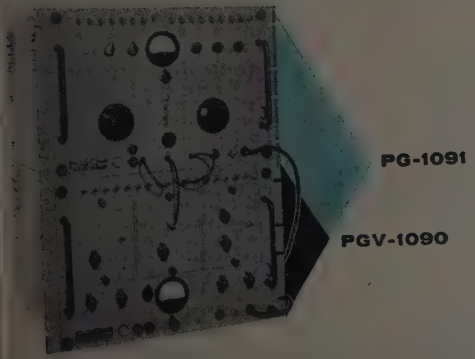
NEW dual purpose RADAR TEST SET

1 Tests MTI radar for sub-clutter visibility and cancellation ratio.

2 Generates precision video and IF pulses for missile guidance and similar applications.



DWE PG-1091 meets every military and commercial requirement:



Model PG-1091 consists of 2 units: IF and video pulse generators, which together measure cancellation ratio and sub-clutter ratio. PGV-1090 (bottom) may be purchased separately for generating a precision video pulse and for checking cancellation ratio.

- LOW SYSTEM JITTER . . . TO WITHIN .0005 μSEC
- FAST PULSE RISE TIME . . . LESS THAN .026 μSEC
- HIGHLY ACCURATE SIMULATED RANGE TO 100 MILES

Primary function: testing and measuring MTI radar sets for cancellation ratio and sub-clutter visibility ratio. Allows a precision adjustment unequalled in any other equipment.

Secondary function: generating precision video and IF pulses for missile guidance and similar applications.

Fully illustrated and described in bulletin DW-104. For your free copy, write Divco-Wayne Electronics, 9701 Reading Road, Cincinnati 15, Ohio.

DWE DIVCO ELECTRONICS

A Division of the Divco-Wayne Corporation

DESIGNERS • ENGINEERS • MANUFACTURERS

Custom built precision mechanical, electro-mechanical and electronic equipment for industry and defense.

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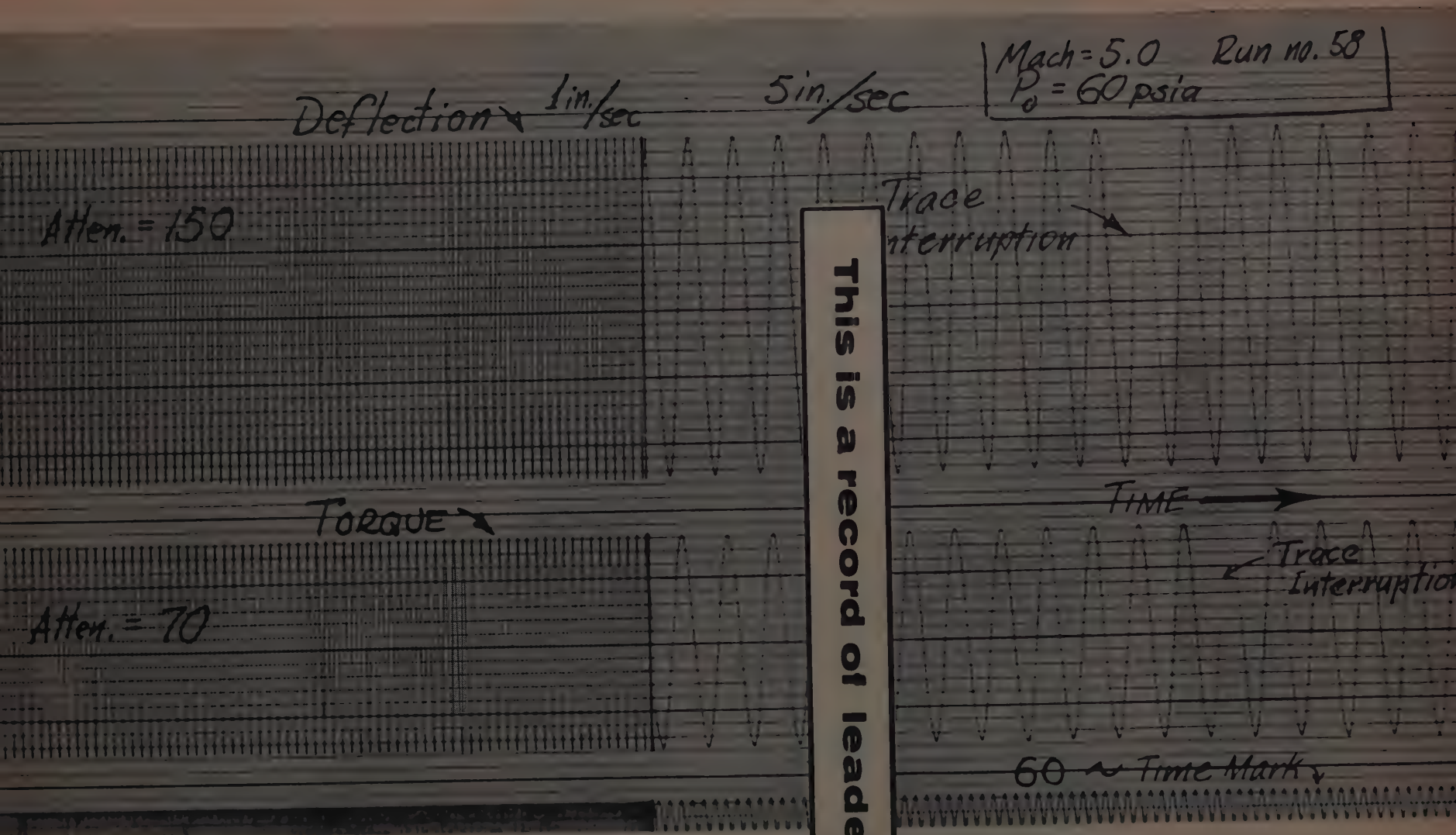

This is a record of leadership

Honeywell 906A Visicorder record, actual size. Note longitudinal grid lines and trace identification interruptions.

These studies of aerodynamic damping coefficients on an airframe were made by engineers at ARO, Inc. They were conducted in the Gas Dynamics Facility at the U.S.A.F.'s Arnold Engineering Development Center, Tullahoma, Tennessee, wind tunnel center of the Air Research and Development Command. The studies were directly recorded on a Honeywell 906-A Visicorder.

The problem: To measure damping-in-pitch derivatives for a clipped-delta-wing-body configuration over a Mach number range of 2.0 to 5.0 so that these measurements could be compared with the Mach number trend predicted by theory.

The set-up: A model of the delta-wing body, mounted on its cross-flexure pivot support, was forced to oscillate through a linkage by an electro-magnetic shaker. Resistance strain gauges were bonded to the input torque member and to one of the pivot supports. These gauges supplied torque and displacement signals through a carrier amplifier to two galvanometers in the Visicorder. An oscillator, driving a third galvanometer, established a time base for the oscillogram.

The values discovered through this forced-oscillation balance system experiment showed some discrepancies from values predicted by theory, because the theory pertained to simpler bodies than that used in the tests. The experiments provided a new set of data which will result in more accurate predictions for future design.

in aerodynamic research

Z. A. Woodard, Jr., ARO, Incorporated, instrument technician, operates the Visicorder in the measurement of aerodynamic damping coefficients.

The Honeywell Visicorder is the pioneer and unquestioned leader in the field of high-frequency, high-sensitivity direct recording oscillography. In research, development and product testing everywhere, instantly-readable Visicorder records are pointing the way to new advances in product design, rocketry, computing, control, nucleonics . . . in any field where high speed variables are under study.

The new Model 906A Visicorder, now available in 8- and 14-channel models, produces longitudinal grid lines simultaneously with the dynamic traces, time lines, and trace identification by means of new accessory units.

To record high frequency variables—and monitor them as they are recorded—use the Visicorder Oscillograph. Call your nearest Minneapolis-Honeywell Industrial Sales Office for a demonstration.

Reference Data: Write for Visicorder Bulletin
Minneapolis-Honeywell Regulator Co.,
Industrial Products Group, Heiland Division
5200 E. Evans Ave., Denver 22, Colo.

Honeywell

Industrial Products Group

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Smaller, Stronger Fasteners for the Aircraft Industry...

the NEW CHERRY 3/32" Self-Plugging Rivet*...

- IN A-286 STAINLESS STEEL
- IN ALUMINUM
- IN MONEL

Where you need the strength of a solid rivet—in those impossible, blind installations—the new Cherry 3/32" Self-Plugging Rivet is the answer.

These Cherry miniature self-plugging rivets are now available in the industry-proven Cherry High Clinch configuration. Ideal for delicate installations in thin sheets with no damage to surrounding material.

A complete line of Cherry 3/32" Hollow Pull-Thru rivets is also available with either universal or 100° countersunk head.

For technical information write to Townsend Company, Cherry Rivet Division, P.O. Box 2157-P, Santa Ana, California.

Patents Issued and Pending

CHERRY RIVET DIVISION

SANTA ANA, CALIFORNIA

Townsend Company

ESTABLISHED 1816 • NEW BRIGHTON, PA.

In Canada: *Parmenter & Bulloch Manufacturing Company, Limited, Gananoque, Ontario*

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COMBINED environments te chamber of GOX lab, shown he with one glass-insulated side ope can provide temperature extreme vibration, rain, etc., simultaneous while flows up to 35 pps are r through the test valve.

bration conditions can all be sim lated simultaneously. A C-25 H 5000-lb or a C-10 BB 1500- vibration exciter can be used.

The chamber can be used wi CO_2, liquid nitrogen, helium, a argon as well as with oxygen. large stainless steel blower, whi has 20,000-W stainless steel he ing elements in it, can circula the gas or liquid at 2000 cf Liquid nitrogen or CO_2 can fed into the chamber from va uum-jacketed transfer lines. The are sprayed into the chamb through a venturi section to p vent a totally saturated atm phere.

The facility also includes a co bined vibration-acceleration cha ber. This unit has an accelera boom with a hydraulic shaker s tem consisting of a two-sta electrohydraulic servo valve c trolling a hydraulically actua cylinder. A swivel joint can attached to the top of the t unit container so that oxyg nitrogen, etc., can be flowed the part is rotated.

Accelerations of over 20 G c be obtained with vibration f quencies up to 250 cps. Work going on to obtain frequencies 500 cps, and the ultimate goal special setups for as much 2000 cps. Ambient temperatu

more on page

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Perception

Looking for an electronics organization with an intuitive grasp of your requirements? Consider BJ Electronics' decade of experience gained in successful development of such diverse products as: Vibrotron transducers and accelerometers, radio-frequency test instrumentation, atmospheric sounding rockets, mobile radar test vans and Northam miniature magnetic tape recorders. Here's a well-equipped, highly creative engineering team able to fulfill your specifications without losing time or sacrificing quality. Consider your problems, then consider our perceptive ability to solve them! ☞ **Write for facilities brochure. BJ Electronics, Borg-Warner Corporation, 3300 Newport Boulevard, Santa Ana, California.**

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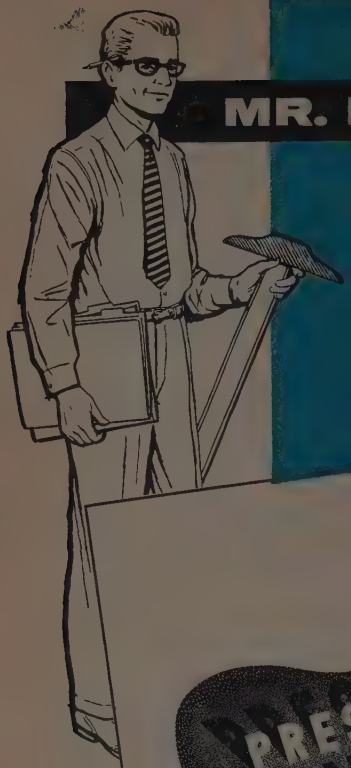

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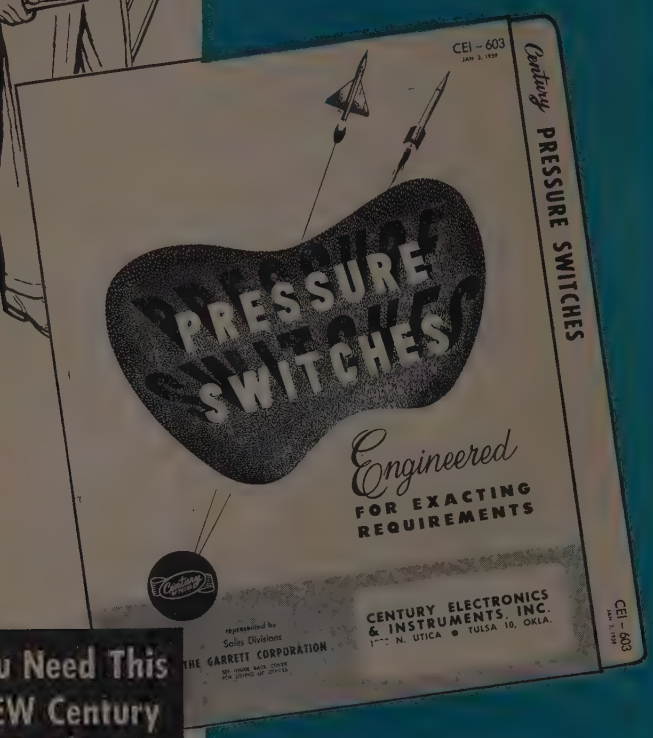

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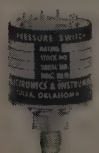
of Precision Pressure Switches



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There is a Century pressure switch precision engineered for every industrial, research, and military application.

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Represented in all principal cities of U.S. by The Garrett Corporation AiResearch and Aero Engineering Division. In Canada by Garrett Manufacturing Corporation of Canada, Ltd.

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VIBRATION POWER supply, housed in lab blockhouse, uses 40-kw Ling TP-40/40-B amplifier.

can be varied from —300 to + 400 deg F.

The shaker can handle payloads of up to 45 lb. A 25-hp hydraulic pump is used for the vibration supply. Write in No. 67 on Reader-Service Card for more information.—**IS**

books

Aerodynamics of Supersonic Flight, by Alan Pope. The second edition of this text includes new material on the practical application of supersonic performance theory and the theory and design of supersonic wind tunnels. Pitman Publishing Corp., 2 W. 45th St., New York, N.Y. $6.

Proceedings of the Fourth Annual Computer Applications Symposium, Chicago, Ill., Oct. 24-25, '57. Papers presented at the meeting covered use of computers for business, management, engineering and research problems. Armour Research Foundation of Illinois Institute of Technology, 10 W. 35th St., Chicago, Ill. $3.00.

Vistas in Astronautics. This is a compilation of the papers presented at the Frist Annual Astronautics Symposium, cosponsored by Convair Div., General Dynamics Corp. Corp. and AFOSR, and held at San Diego, Calif., Feb., '57. Pergamon Press, 122 E. 55th St., New York 22, N.Y. $15.

NEW!

SMALL!

DELCO POWER TRANSISTOR

Designed for use where space and weight are restricting factors

MAXIMUM RATINGS	2N1172
Collector Diode Voltage	40 volts
Emitter Diode Voltage	20 volts
Collector Current	1.5 Amperes
Junction Temperature	95°C
TYPICAL CHARACTERISTICS (25°C)	
Max. Collector Diode Current I_{co}— V_{cb}=40 volts	50μ
Current Gain (V_{ec}= −2 volts, I_c=100 Ma)	70
Current Gain (V_{ec}= −2 volts, I_c=1A)	30
Saturation Resistance	0.3 ohms
Cutoff Frequency (Common Emitter)	25 kc
Thermal Resistance	7°C /Watt

The 2N1172 is a medium power transistor offering dependable operation in a new range of applications where space and weight have been a problem.

It's a mighty mite with more punch in a smaller package. The 2N1172, excellent for output use or as a driver for a very high power transistor, has already proved especially effective in DC amplifiers, voltage regulators, and as a driver for a high power stage in servo or other amplifiers.

This PNP germanium transistor is housed in a modified version of the JEDEC 30 package with a diamond shaped base for improved thermal conduction. It dissipates 2 watts at a mounting base temperature of 70 degrees centigrade. Available now in volume production—write today for complete engineering data.

DELCO RADIO

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IS
NO
BETTER
WAY
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LIQUID OXYGEN

Liquid oxygen is the safest, most efficient oxidizer commercially available for missile and rocket propulsion systems. It is stable, non-toxic, non-corrosive, and easy to dispose of when necessary. That's why it is used in IRBM and ICBM motors.

Large volumes of liquid oxygen can be stored indefinitely in LINDE designed and built storage units — right where it is needed. Vaporization losses are minor — can be held to *less than 5 per cent per year.*

Using LINDE's methods, liquid oxygen can be transferred safely from storage — without pumps — ten times faster than previously.

LINDE can supply large quantities of liquid oxygen almost anywhere in the nation—quickly, and at a cost of only pennies per pound.

If you are concerned with the nation's vital missile and rocket development program, take advantage of LINDE's more than 50 years of experience in producing, transporting, and storing liquid oxygen. Call the LINDE office nearest you, or write: LINDE COMPANY, Division of Union Carbide Corporation, Dept. J-4, 30 East 42nd Street, New York 17, N. Y.

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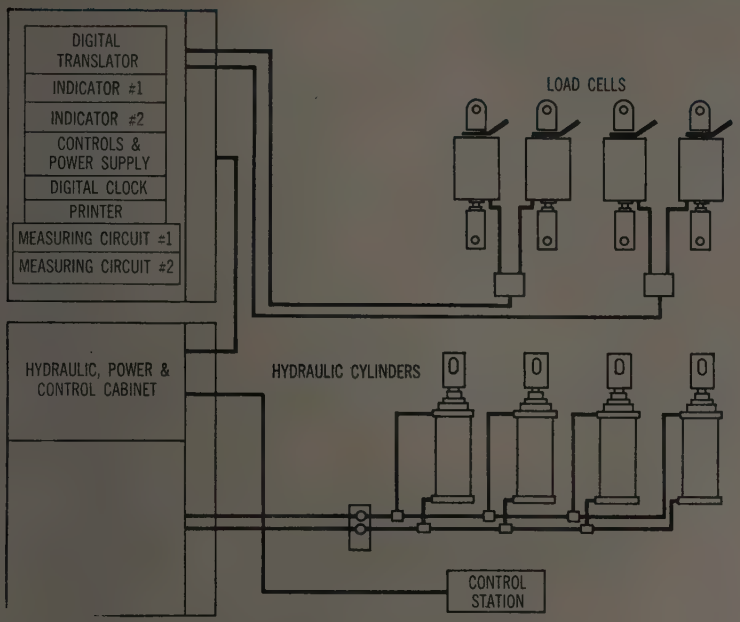

FIGURE 1: Field calibration standard.

Ground Support

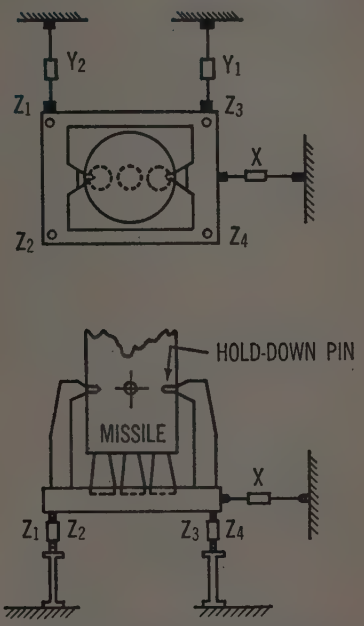

FIGURE 3: Load cell arrangement for force component measurement.

Load cells measure Atlas weight and thrust to 50 lb

Load cells attached to the Atlas ICBM launching platform are used to measure and record the missile's empty and fueled weight and to resolve thrust force buildups during tests and actual launchings. A separate set of cells is used to check out the weight and force measurement system.

by R. J. Carleton, Jr., Vice President & Chief Engineer, Gilmore Industries, Inc.*

LAUNCH pad force measuring systems are used for ballistic missile fueling, static engine testing, and flyaway firings. A combination static and dynamic design, such as is used for the Atlas ICBM, measures not only the magnitude and direction of thrust but also records the side forces and moments.

During static tiedown tests, hold-down pins carry the full thrust loads to seven load cells that keep the platform restrained in the X-, Y-, and Z-axes (*Fig. 1*). For launching, the hold-down pin arms are flung out to release the missile when the thrust has built up to a predetermined level.

While the missile is being readied for test or launching, the Z-cells register the weight of the missile and propellant. As a result, it is easy to find empty weight as the missile is placed on the launcher frame and then weigh (and meter) the propellants as they are added. Any oxidizer boil-off during "hold" periods shows up as a loss in weight that can readily be used to penetrate as a replenishing signal to supply more oxidizer to the propellant system.

For the Atlas, the weight indicator is located in a block house 1000 ft away from the pad. Instrumentation is set up to measure missile and propellant weights to

more on page 118

*Gilmore Industries, Inc., 13015 Woodland Ave., Cleveland, Ohio

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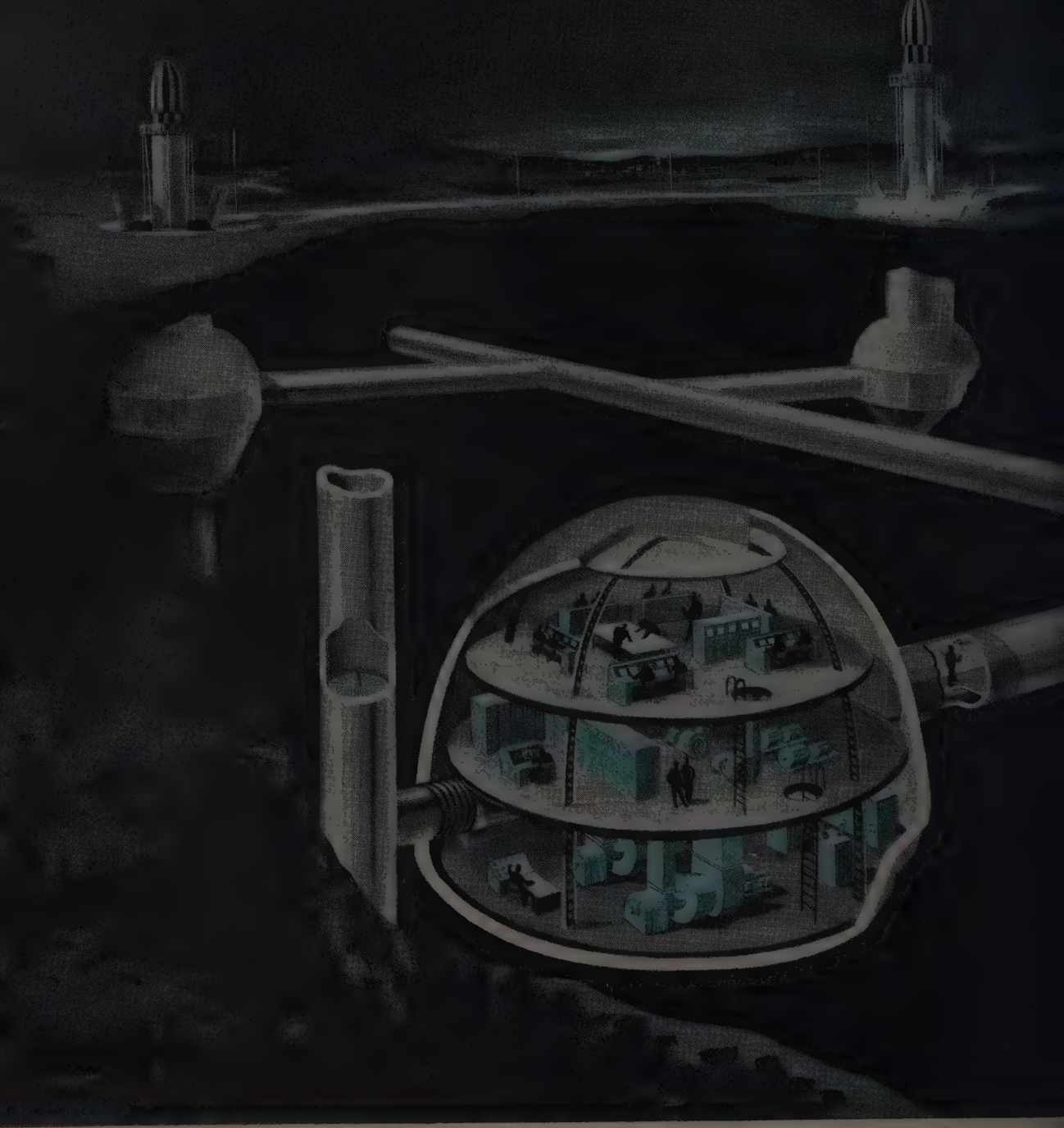
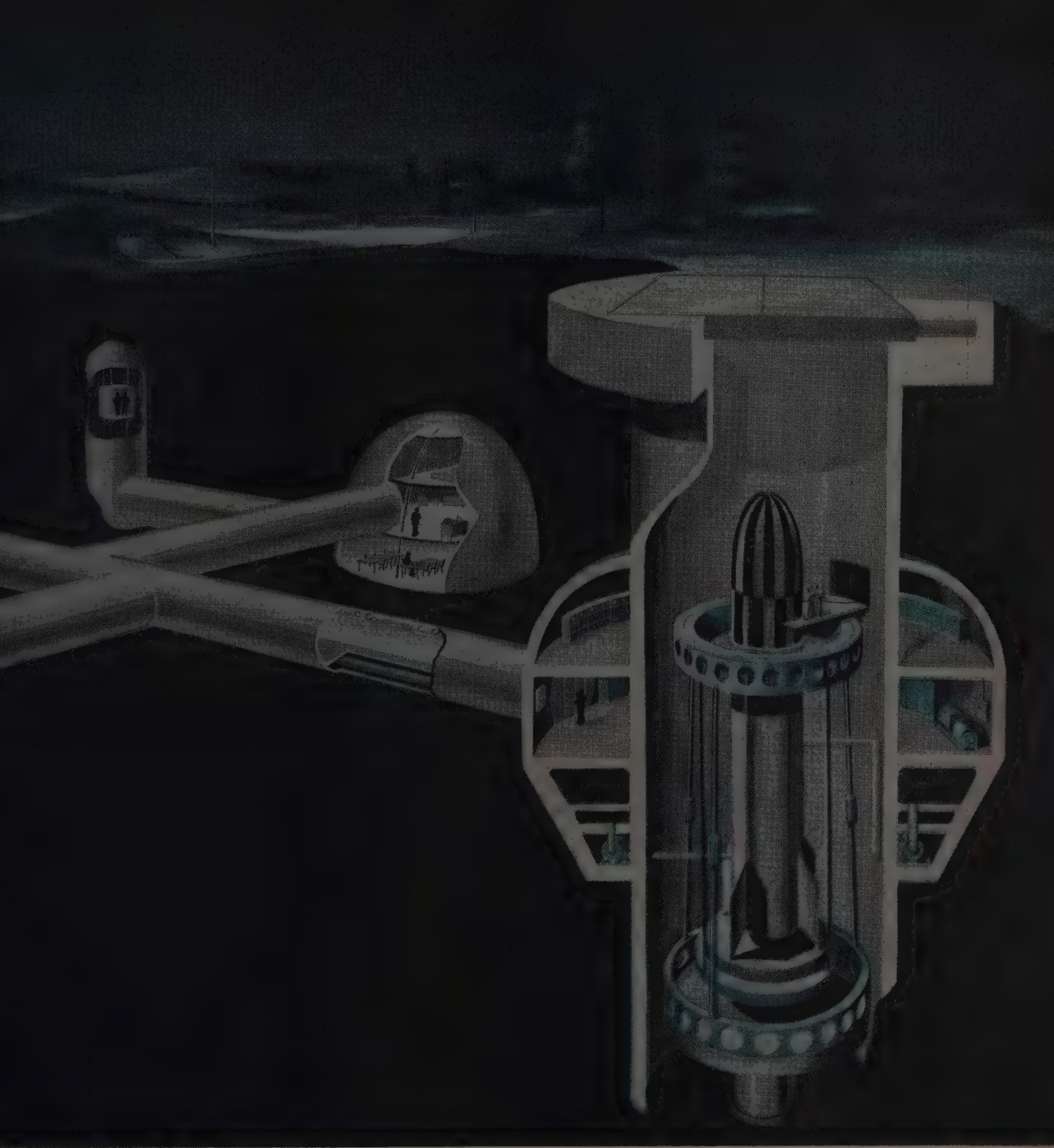


from Westinghouse... equipment

Westinghouse has been building shock-proof electrical, electronic and mechanical equipment since 1940 . . . In fact, Westinghouse makes more types of apparatus for high shock applications than any other manufacturer . . . turbines, gears, generators, switchgear, transformers, motors, control, elevators and electric stairways, lighting, air handling and conditioning equipment, microwave communication systems and many other devices and components.

Whether above ground or below, soft or hardened, defense installations require a great variety of equipment which must operate without fail as individual units *and* as elements of interrelated systems. As a supplier to the Government and to general, electrical and mechanical contractors, Westinghouse provides system-coordinated applications of standard or shock-proof apparatus which assure the most reliable and economical installations.



for hardened missile bases

Take advantage of this Westinghouse experience, product range and application coordination to insure system performance and shortest installation and acceptance times. Contact your Westinghouse sales engineer or write Westinghouse Electric Corporation, 3 Gateway Center, P. O. Box 868, Pittsburgh 30, Pa. Copies of this illustration suitable for framing are available when requested on your letterhead.

J-92023

Artist's conception of a possible hardened missile site, showing in blue some of the shock-proof equipment which Westinghouse can supply.

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the nearest 50 lb and to print out the readings on a tape for permanent record (*Fig. 2*).

The load cells and readout equipment for the Atlas stands were originally calibrated away from the launcher frame and then installed. This meant there was no way of precisely compensating for the weight contributed by the many cable conduits and propellant servicing pipes extending from the gantry to the missile.

The original calibration itself naturally may no longer apply after an extended period, so that some sort of weight standard is needed to check out the system. As designed for the Atlas (but also applicable to other missiles), the standard basically consists of four additional load cells, each with a hydraulic jack, and a mechanical system of loading the launching pad. This mechanism reaches up from the base structure, grasps the launcher platform, and pulls down in a manner that simulates the weight of the missile resting on the launcher frame.

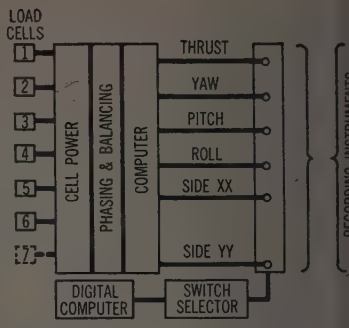
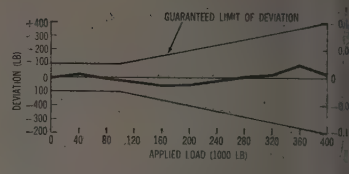


FIGURE 2: Typical six-component force measuring system and instrumentation. Recording instruments are: 12-in.-wide strip chart recorder, high speed pen recorder (up to 60 cycles), very high speed photographic recorders (up to 1000 cycles), digital servo indicator, analog tape recorder, and digital tape recorder (with analog-digital converter).



TESTS made by Bureau of Standards show practically no error in load cell measurements over full range of applied loads.

This secondary set of load cells (*Fig. 1*) has a Bureau of Standards calibration and is free from the interference of pipes and cables. It records the exact pull of the hydraulic cylinders acting on the launcher platform as true weight which can then be compared with the weight recorded by the permanently installed working cells.

The basic use of the calibration standard is to check out the field installations for possible correction. The operational equipment must be checked to see if the original calibration holds over a number of firings and to find out if there is any weight absorption due to the attachments between the missile and its gantry. Write in No. 52 on Reader Service Card for more information.—End

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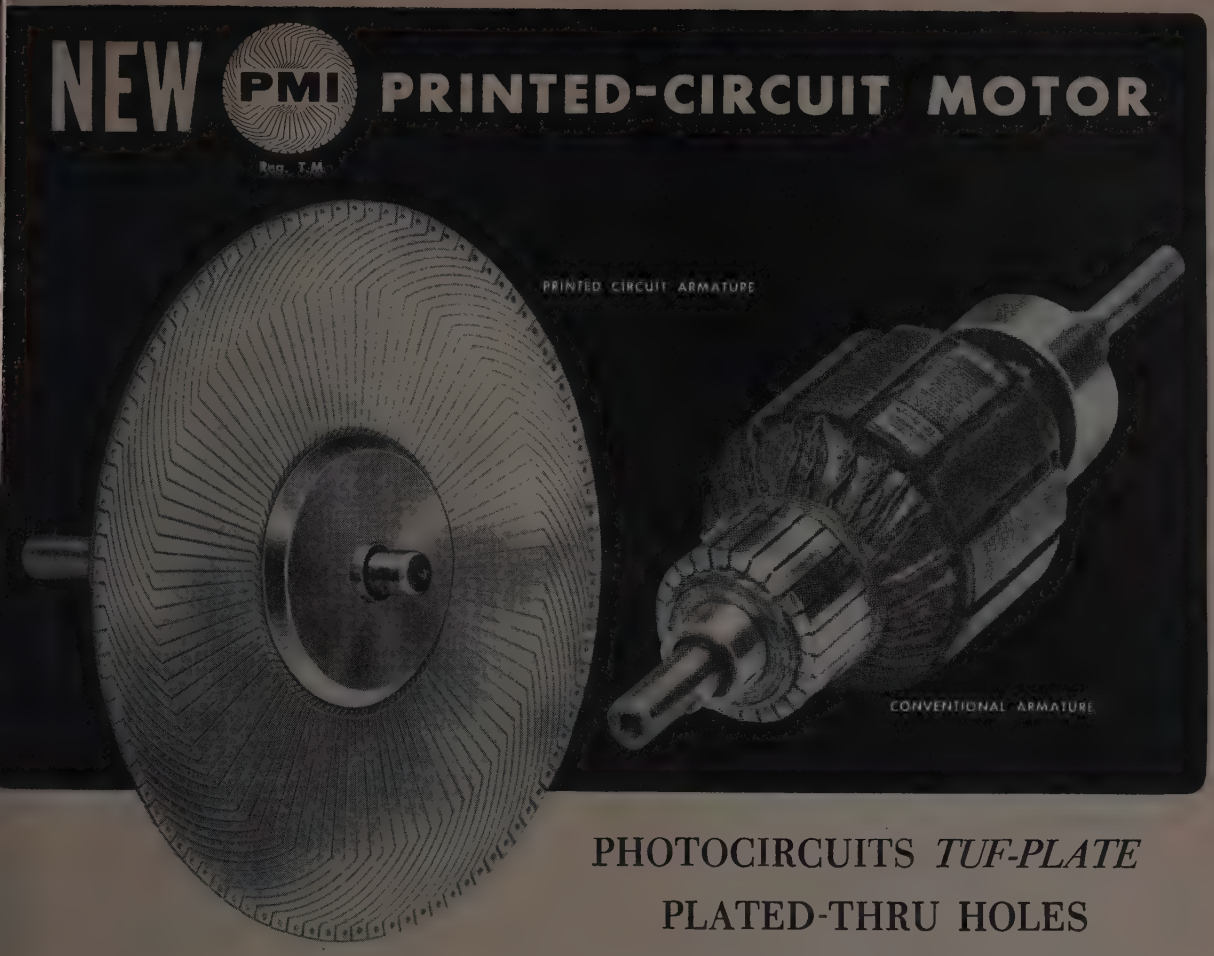
NEW PMI PRINTED-CIRCUIT MOTOR

Reg. T.M.



PHOTOCIRCUITS *TUF-PLATE* PLATED-THRU HOLES *NOW* MAKE POSSIBLE THE

st MAJOR CHANGE IN MOTOR DESIGN IN 50 YEARS

Revolutionary new motors using a thin inexpensive printed circuit as the rotating electrical element are now available. Heavy iron armatures, and cumbersome windings are eliminated; insulation breakdown is no longer a problem, insuring reliability in product design.

More exciting features . . .

low armature inertia — mechanical time constants of a few milliseconds
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low impedance — suited for operation with power transistors
smooth torque — no cogging, direct drive in servos
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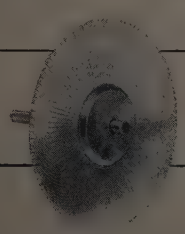
Why delay, contact Photocircuits, exclusive manufacturer of printed motor components for Printed Motors, Inc. (holder of North American patent rights for the printed motor technique).



PC **Photocircuits** CORPORATION

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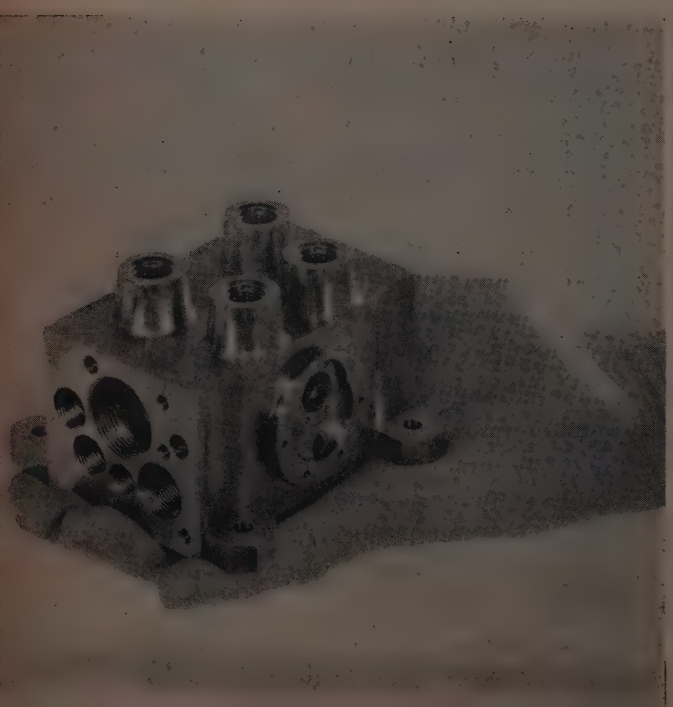
How Titanium licks the weight bogey in components . . . A STUDY IN MACHINING SUCCESS

Today's aircraft component manufacturers are getting squeezed from two directions: Weight allowances of complex parts are being drastically reduced . . . but redesign costs to shave off a few ounces of excess "fat" cannot be written off in the short-run orders of the current market.

What can the manufacturer do? Should he trade profit for good will, or should he simply give up, and yield his position in a market with such excellent potential?

Titanium Metals Corporation of America has found increasing case-history evidence that an economically sound compromise exists: Substitution of titanium for heavier materials, on a volume basis. The results: a lighter assembly; elimination of redesign costs; and no extensive equipment purchase or modification.

Best news of all, the finished product can be marketed competitively. Here's the proof:



There's an old chestnut, held over from several years ago, that titanium is next to impossible to machine. This belief goes back to the time when fabricating techniques for this new material were still being developed. Today, though, the picture has changed:

". . . prefer machining titanium to . . . stainless steel . . ."

Cadillac Gage Company, Warren, Michigan, has substituted Ti-75A titanium for a high-nickel alloy in valve housings designed for North American Aviation's A3J Navy attack aircraft.

Titanium *combines* the properties that ordinarily require a series of materials. Lightweight titanium is non-magnetic, corrosion-resistant and retains its great strengths from −300°F to +1000°F. What does titanium mean to Cadillac Gage in production of valve housings?

Weight saving: 2½ lb. Size of contract: $100,000.

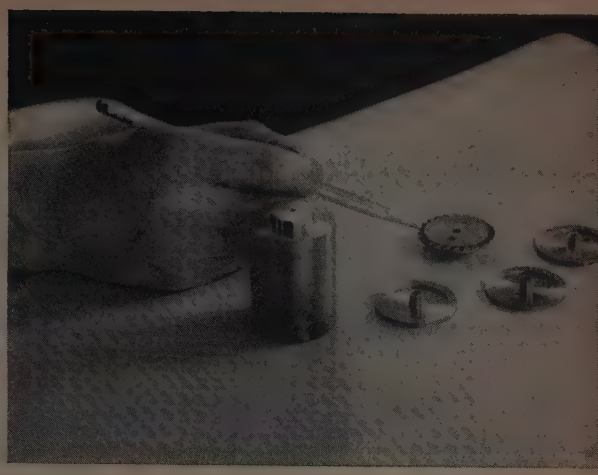
Project Engineer Robert Moffatt states: "Our shop personnel actually prefer machining titanium to some grades of stainless steel. And the use of titanium has added no more than 5% to 10% to the final cost of the valve."

ease in machining . . . competitive with plastics . . ."

Fischer Machine Company, Philadelphia, Pennsylvania, machines titanium on conventional equipment, holds tolerances to 0.0002" on ½-ounce turbine wheel 1¾" in diameter, has contracts for $60,000 in titanium parts.

The turbine wheel, which actuates the generator in Philco's 155-pound Sidewinder missile, reaches speeds of 60,000 rpm. in a fraction of a second. The application calls for a low density material with great strength and heat resistance. Fischer employs annealed Ti-6A1-4V (130,000 psi tensile; density 0.163 lb./cu. in.) for the job.

General Manager John Sutton says: "Recent price reductions and our ease in machining have combined to make the prices of our turbine wheels competitive with machined plastic wheels. There is, of course, a price difference — but that's more than settled by titanium's vastly superior performance."

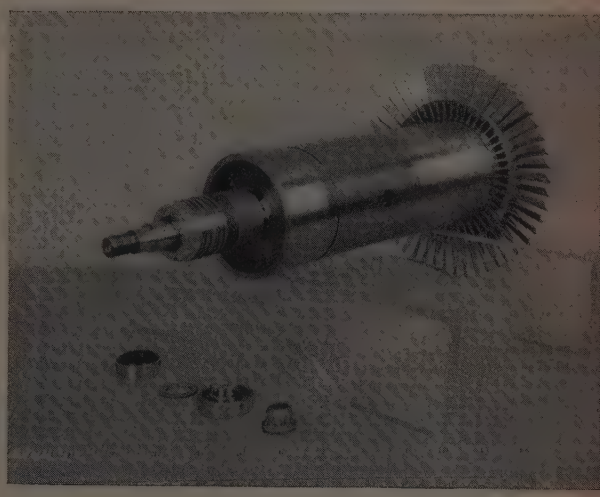


tanium helps hold rotor weight to 20 pounds . . .

General Electric Company, Lynn, Massachusetts, has introduced a new concept in electrical power generation which combines the generator and turbine into a single self-cooling unit. It's called the Turbonator.

Turbine and rotor — both on a common shaft — operate at 24,000 rpm. Titanium substituted for steel in top sticks and retaining rings enables GE to hold rotor weight to 20 pounds, and achieve efficient turbine speeds, because non-magnetic titanium can withstand high centrifugal forces.

John W. Harrison, project engineer, reports: "The Turbonator cuts package size 50% and cost 20% from conventional turbine-generator systems. It's versatile and can be used anywhere there's a jet engine."



These findings highlight two things: the growing concern of airframe makers over weights of purchased parts; the feasibility of constructing with titanium, instead of redesigning to combat excess weight.

The key to effective use of titanium lies in overcoming ingrown fears relative to machining.

For example, titanium has a low work-hardening rate, low coefficient of friction, low shearing force and freedom from notch sensitivity — all contributing to its relatively good machinability.

Commercially-pure grades (Ti-55A, Ti-65A, Ti-75A) in general, machine similar to the 300-series of stainless steel. Alloy grades (Ti-6A1-4V, Ti-7A1-4Mo, Ti-155A, Ti-5A1-2.5Sn) are similar to the 400-series.

Use of sharp tools (replaced at first signs of wear), high feeds, slow speeds, and liberal amounts of coolant enable fabricators to achieve economical production runs.

Titanium Metals Corporation of America is always ready to help you take full advantage of titanium's excellent combination of design properties, by providing a steady flow of information on fabrication techniques, and maintaining a referral program by which prime contractors may locate component manufacturers of demonstrated ability.

Entrance into titanium now can mean immediate contracts and establish your firm in the long-term future. Contact the TMCA sales office in the city nearest you for further information on how titanium can help you.

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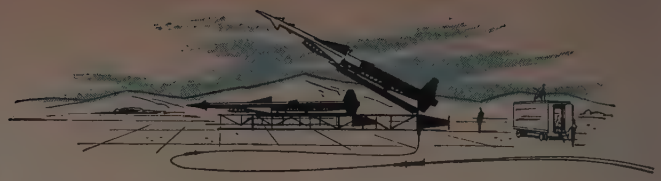

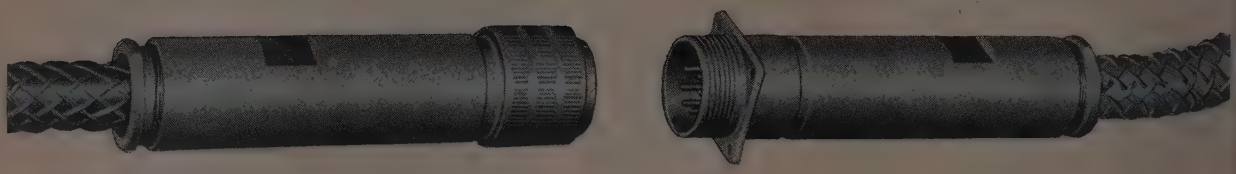

Why it pays you to specify

Bendix QWL Electrical Connectors for use with Multi-conductor Cable

For use with multi-conductor cable on missile launching, ground radar, and other equipment, the Bendix* QWL Electrical Connector meets the highest standards of design and performance.

A heavy-duty waterproof power and control connector, the QWL Series provides outstanding features: • The strength of machined bar stock aluminum with shock resistance and pressurization of resilient inserts. • The fast mating and disconnecting of a modified double stub thread. • The resistance to loosening under vibration provided by special tapered cross-section thread design. (Easily hand cleaned when contaminated with mud or sand.) • The outstanding resistance to corrosion and abrasion of an aluminum surface with the case hardening effect of Alumilite 225 anodic finish. • The firm anchoring of cable and effective waterproofing provided by the cable-compressing gland used within the cable accessory. • The watertight connector assembly assured by neoprene sealing gaskets. • The additional cable locking produced by a cable accessory designed to accommodate a Kellems stainless steel wire strain relief grip. • Prevention of inadvertent loosening insured by a left-hand accessory thread. • The high current capacity and low voltage drop of high-grade copper alloy contacts. Contact sizes 16 and 12 are closed entry design.

These are a few of the reasons it will pay you to specify the Bendix QWL electrical connector for the job that requires exceptional performance over long periods of time. *TRADEMARK

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Reversed bolt jams controls

JUST AFTER TAKEOFF, a bomber turned rapidly into a nose-high attitude. The crew could not correct this immediately. Nose-down elavator pressure had no effect—the control column apparently was locked in the full back, nose-up position, **Flight Safety Foundation, Inc., 468 4th Ave., New York 16, N.Y.,** reports in Bulletin 58-8.

Various combinations of landing flap settings, stabilizer trim tab, airspeed, air brakes, etc., were tried. Finally, after a long time, enough control over longitudinal attitude was available to try a landing with reduced fuel load.

On the first try, the nose dropped sharply because the stabilizer trim action was too slow. Four more attempts were made. The fifth brought the bomber in.

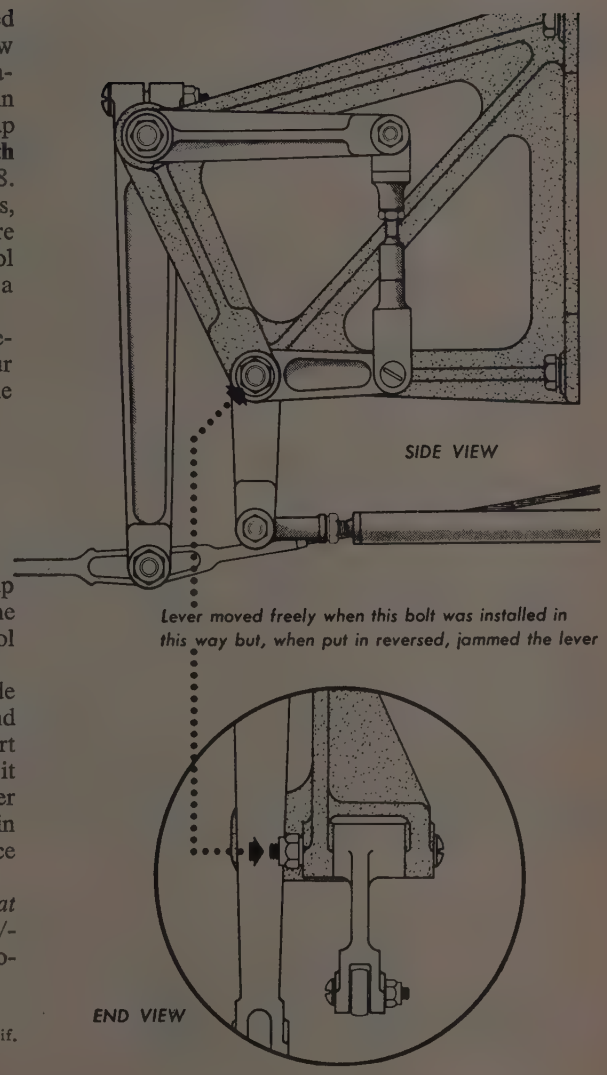
THE HAZARD

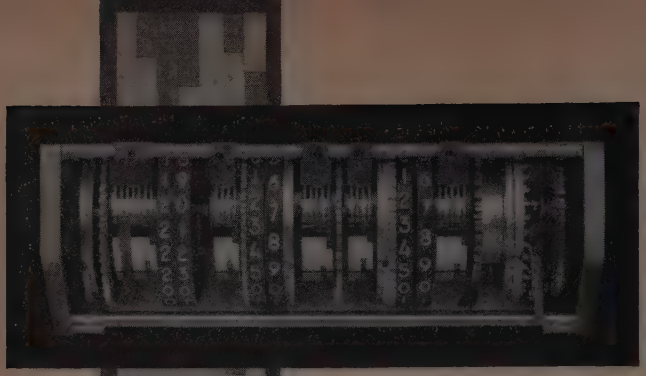
It was found that the elevator control lock-up was caused by a bolt installed in reverse. The threaded portion protruded, jamming a control lever.*

Design of the mechanism failed to provide against the bolt's being installed in reverse, and "Murphy's Law" took effect: "If an aircraft part can be installed incorrectly, someone will install it that way." Minimum clearance between the lever and bolt head existed when the bolt was put in correctly. But reversing the bolt reduced clearance to interference.

How would you design this mechanism so that the bolt could not be installed incorrectly? (SPACE/AERONAUTICS will publish a limited number of proposed designs submitted in simplified form.)

*Directorate of Flight Safety Research, USAF, Norton AFB, Calif.





. . . Kearfott analog-to-digital converters

accuracy, reliability, varied capacities and codings

Kearfott's direct drive converters translate shaft rotation into electrical and visual digital form. These mechanically positioned units consist of coded drums, the number depending on the code and total count. The first, or units drum, connects directly to the input shaft and rotates as the shaft turns. On models where more than one drum is used, high speed odometer type gearing provides interconnection. All models can be read "on the run" or "on demand" and all tracks may produce simultaneous or serial readings, depending on the interrogating pulse.

The high performance and quality of Kearfott's analog-to-digital converters are assured by stringent testing for:

Mechanical Accuracy: The location of any code transition point must fall within one-third bit of its true angular position.

Low and High Temperature: All units operate efficiently at temperatures ranging from — 65° F to + 260° F.

Brush Skip: Conducted in conjunction with tests for temperature, vibration, shock and acceleration. A typical brush skip test employs 200 μsec., 23V DC amplitude interrogating pulses at 4000 cycles per second. With the shaft rotating, each output drum track is monitored for a total of 500,000 pulses, in which "lost" counts or "skips" will not exceed 1 in 15,000.

Shock: Kearfott converters are subjected to 18 shocks in three different planes with shock loading of ± 15 g's.

Vibration: Units must withstand vibrations between 5 and 500 cps with applied load of ± 10 g's.

Acceleration: All units are subjected to radial accelerations of varying magnitudes up to a maximum of ± 7.5 g's.

Life: Over 1 million linear feet (1000 hours at 82 RPM) of continuous brush travel on drum coded patterns can be achieved without excessive wear to drums, brushes or other sub-components.

Write for new ADAC brochure.

ANALOG-TO-DIGITAL CONVERTER CHARACTERISTICS

Kearfott Unit No.	423830-1	423607-1	Y1241-11A	P1240-11A	Y1240-11A	U1240-11	P1241-11A
Code (1)	B.D.	B.D.	B.D.	B.D.	B.D.	B.D.	C.B. (Gray)
No. of Drums	1	1	2	3	3	4	5
Range	0 to 84 in 348.5° of arc. 11.5° dead spot coded O	—19 to 0 to + 19	0 to 359	(+) 0 to (+) 999 (—) 999 to (—) 0	0 to 359.9	0 to 359.9	0-32,768 (2^{15})
Bits per Revolution	85	39	40	20	40	40	16
Revolutions for Total Range	1	1	9	100	90	90	2,048
Volts D.C.	23	12	23	23	23	23	10.5
Current (ma.)	20	20	20	20	20	20	20
Inertia (gm. cm.²) (2)	158	48	104	28	158	100	20
Unit Diameter (in.)	2⅛	1¾	1 15/16	1⅞	1 15/16	1.875	1⅞
Unit Length (in.)	31/32	1 1/16	1-43/64	1 15/16	2 3/16	2.8125	3
Life (3)	10^6 revolutions or 10^3 hours						
Static Torque (in.-oz.) (4)	0.5	0.1	1.0	.5	1.0	1.0	2 (break) 1 (running)
Weight (oz.)	5	3.5	5.75	4	7.75	6.5	5
Maximum Speed (RPM)	1100	250	300	400	300	700	600
Dielectric (Volts DC)	500	500	500	500	500	500	500

(1) B.D. (Binary Decimal), C.B. (Cyclic Binary).
(2) Inertia measured at maximum trip.
(3) Under recommended conditions.
(4) At room temperature.

Engineers: *Kearfott offers challenging opportunities in advanced component and system development.*

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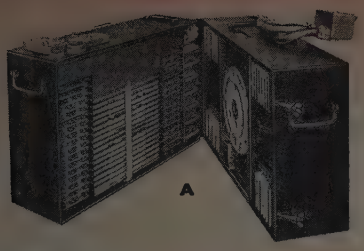
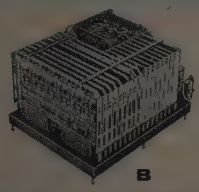


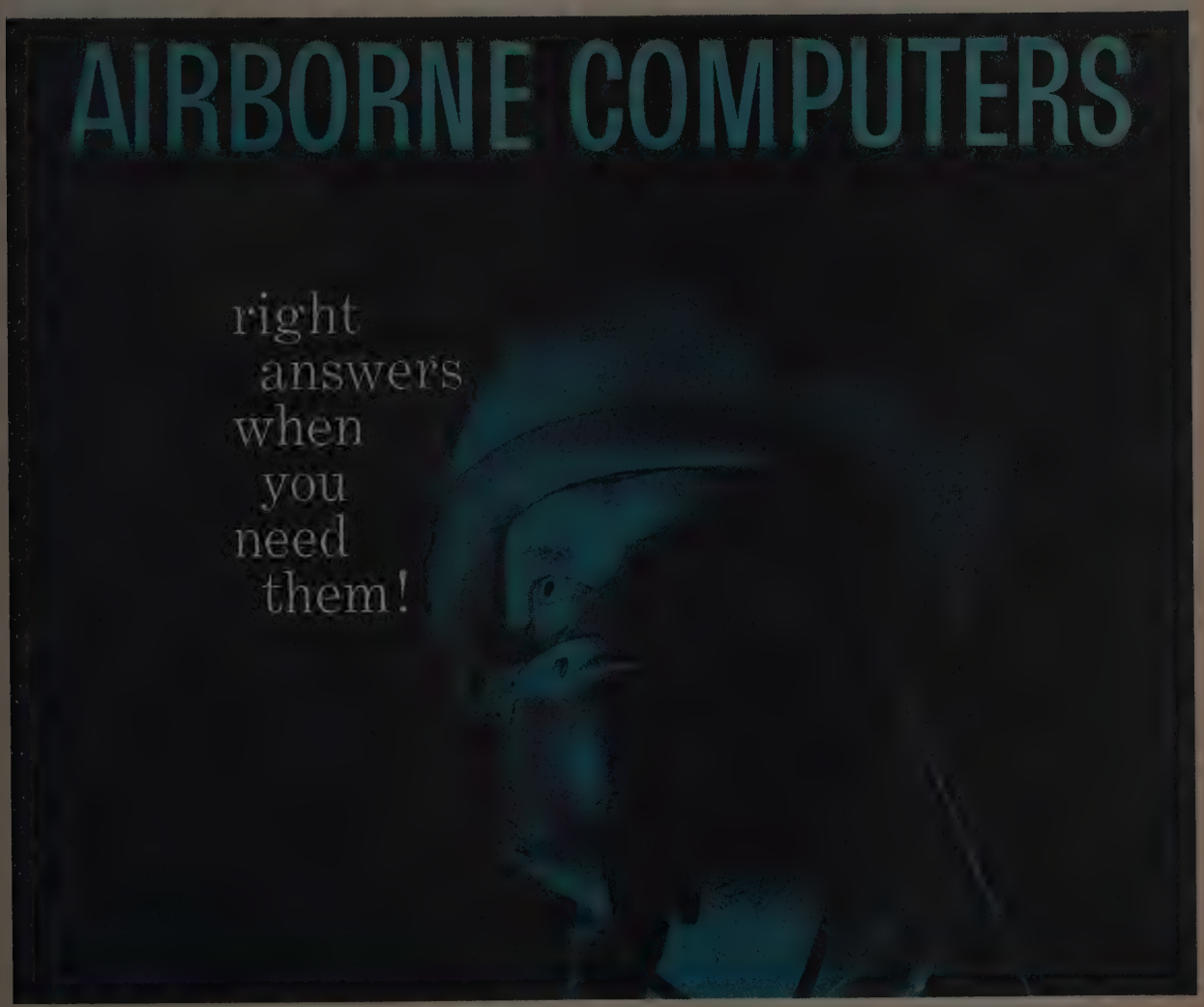
LIBRASCOPE AIRBORNE COMPUTERS*



IN A CLOUDED MOMENT OF DECISION, Librascope Airborne Digital Computers read-out accurate data . . . providing fire control, auto-navigation and bombing information ■ *The reason:* experienced Librascope engineers conceive and design computers and systems compatible with input data. Optimum system accuracy and reliability at minimum size and weight is achieved. ■ In the field, Librascope Airborne Computers are proving the dependability predicted in laboratory tests. Many military systems rely heavily on Librascope equipment and controls for right answers when they need them. *Adaptable to your needs are our two decades of experience creating* COMPUTERS, CONTROLS, *and* SYSTEMS *for both military and industrial use.*

AIRBORNE COMPUTERS

right answers when you need them!



For information on career opportunities at Librascope, write Glen Seltzer, Employment Manager.

* Typical of Librascope's leadership in airborne digital computers are: **A** Incremental digital computer for Navy aircraft calculating bombing and navigation information. (Developed in 1954.) **B** Small transistorized general purpose digital computer for such problems as auto-navigation for aircraft and missiles. (Developed in 1958.) For detailed information on how Librascope solutions can apply to your computer systems problems, write...

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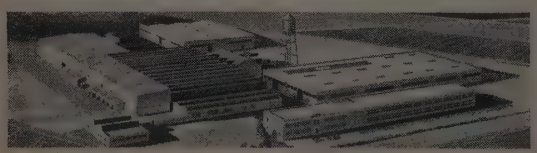
NAVY SELECTS RYAN C-W DOPPLER NAVIGATORS FOR MAJOR AIRCRAFT

Six major types of Navy aircraft will be equipped with Ryan continuous-wave Doppler navigation systems, the AN/APN-122 (V), under an initial $20-million contract awarded by the Navy to Ryan's Electronics Division. Ryan's automatic, all-weather, self-contained navigators will be installed in the Navy's Lockheed Neptunes (P2V), Martin Marlin patrol planes (P5M), carrier-based Douglas Sky Warriors (A3D), and three types of Grumman aircraft.

Developed in cooperation with the Navy, these advanced electronic systems are the lightest, simplest, most compact, and most reliable of their type. The new order, one of the largest of its kind, emphasizes Ryan's leadership in navigation and guidance systems.

With a solid backlog of this and other important contracts for RYANAV systems, the Ryan Electronics Division is growing even faster than this fastest growing industry. Personnel and facilities are being doubled, both in the new production plant at Torrance, Calif. and at the San Diego facility, where a modern new electronics research center is under construction.



New electronics production facility at Torrance (near Los Angeles).

New electronics research center at San Diego.

Ryan's rapid growth in electronics is creating new opportunities for engineers and technicians

RYAN BUILDS BETTER

ELECTRONICS DIVISION

Ryan Aeronautical Company, San Diego, California

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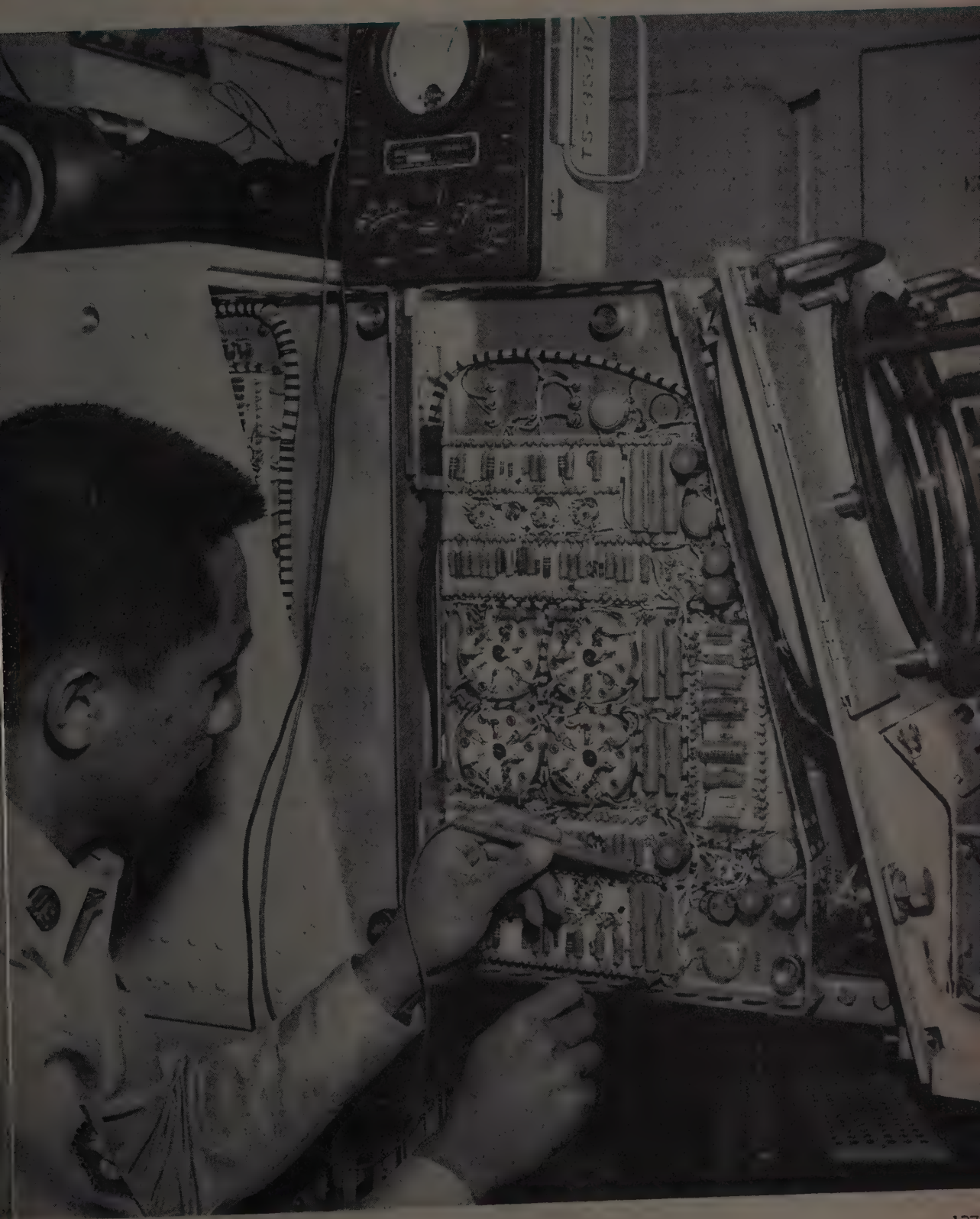
space aero Electronics



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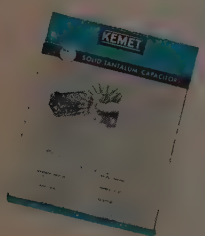

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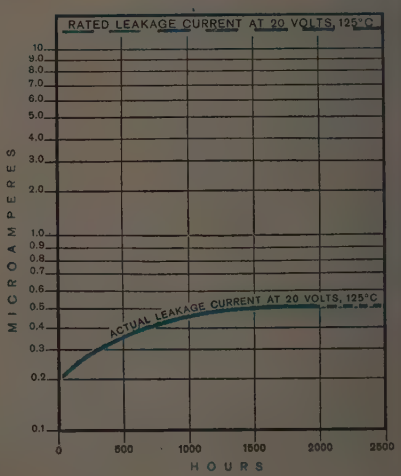

LEAKAGE CURRENT vs. TIME AT 125° C
"KEMET" K5H30 SOLID TANTALUM CAPACITOR
(Average of Typical Capacitors)

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space/aero electronics intelligence

RCA hopes to develop entire family of Nuvistors

NUVISTOR, the vacuum tube industry's latest and possibly most potent answer to the transistor challenge, was introduced by RCA's Receiving Tube Division. Simple in construction, it is about half the size of equivalent miniature versions, dissipates about half the heater power, uses less than half the plate (and screen) voltages.

Because of its simple construction, it will be easy to assemble mechanically, says RCA. It is exceptionally rugged. RCA expects to make Nuvistors with useful lifetimes of "tens or even hundreds of thousands of hours."

COMPARED WITH the transistor, the Nuvistor will have better power frequency, and voltage and current capabilities, claim the device's designers.

The concept has been applied to a small signal triode and a small signal tetrode, but RCA hopes to develop entire families of Nuvistors. Development samples will be available to design groups shortly. First production is planned for early '60.

Nuvistor's have stood 850 G transverse shock and more than 5000 cps vibration at two G. They will operate between —190 and +350 deg C.

Ten-year Project 480L communications system to meet AF needs beyond '70

BILLION DOLLAR communications support system will expand, modernize, and integrate Air Force's world-wide, long range, point-to-point and air-to-ground Stratcom network. The 10-year Project 480L will provide communications for USAF's weapon requirements until '70 and beyond. The voice capacity of the present system will be quadrupled; the data transmission processing capability will be increased tenfold.

The following USAF systems will be integrated into 480L: Ballistic Missiles Early Warning System (224A); Tactical Air Command Continental (314L); Log Data (423L); Weather Data (433-L); Intelligence Data (438L); Air Traffic Control (431L); Sage (216L); DEW (213L); SACCS (465L), and Material Handling (463L). Of these, only Sage and DEW are now operating.

ITT AND RCA are responsible for design and master planning of 480L as associate contractors, with ITT the senior partner. Hughes and Hoffman Electronics are principal subcontractors.

Western Electric and teams headed by Philco and Westinghouse had also bid on the project but lost out to the ITT-RCA combination.

PRESENT VERSION of Stratcom consists mainly of landlines, radio, and underwater cables. It is vulnerable to jamming, says USAF, and depends on the stability of our foreign alliances.

USAF, Army, and Navy have agreements to use each others facilities. Project 480L will see that the new system is compatible with Army's and Navy's.

Toughest part of global comm net is the Pacific area, claims USAF. Here tropospheric transmission is not suitable, because of the long distances, and ionospheric transmission is inadequate.

The whole 10-year 480L program could cost $3-5 billion, it is speculated. USAF has set aside $3 million from '58 and '59 funds to begin the planning phase of the project.

Record link of 406,620 miles to Pioneer IV

LONGEST communications link in the history of man was made between Pioneer IV and tracking station at Goldstone Lake, Calif. Sun satellite's signals were picked up from some 406,620 miles out in space. (Reds reported receiving signals from Lunik when it was around 370,000 miles away.)

Mercury cells in Pioneer IV are believed to have lasted for about 90 hours.

●

EMPHASIS in maser research has turned to traveling-wave masers. TWMs are essentially non-reciprocal, eliminating the need for external isolators and circulators. Because of their slow-wave propagation structure, they take advantage of the full emissive bandwidth capabilities of the maser material. TWMs can be tuned by simply changing the frequency of the pump and the magnetic field strength.

Cavity-type masers, on the other hand, need circulators or isolators, and their low noise ad-

more on next page

Cover story—Entire console section of Frescanar, Hughes Aircraft's mobile electronic-scan radar, pulls out for trouble-shooting. High accessibility plus replaceable modules allow Signal Corps to keep set in 24-hour operation.

vantages are compromised by losses in these components. They are also vulnerable to saturation sensitivity—a signal in the order of microvolts will saturate them. Because of their relaxation time, they take a certain time, once they are saturated, before they start working again. Saturation can be prevented at these low levels by using a more refined duplexer or by tailoring the relaxation time to the system. Such mods, however, lead to lower gain-bandwidths and higher pump powers.

TOUGHEST POSER in automatic landing will be tackled by Gilfillan under contract to FAA. The company will attempt to make an experimental electronic system that will give the pilot (or autopilot) elevation information during the final phase of the approach up to touchdown. With current approach systems (ILS and GCA), elevation information deteriorates as the ground is approached.

GILFILLAN proposes to use a ratio beam scanning technique to establish a "grid in space". Three-dimensional information will be sent to the landing system so that it may derive its position and approach path.

Should this phase of the automatic landing be solved, FAA will integrate the new device with an approach aid to form a complete approach and landing system.

High speed digital computer used in carrier plane traffic control system

EXPERIMENTAL traffic control system for Navy aircraft carriers was developed by Cornell Aero Lab. The "wave-off and transition control unit" (WOTCU) controls aircraft from a few miles aft of the carrier to the point at which the automatic landing system takes over. Planes waiting to land fly in an assigned block of airspace in a hexagonal pattern. If an aircraft gets a wave-off, WOTCU quickly fits it back into the stream of incoming traffic.

A high speed digital computer is the heart of the system. It calculates speed, heading, and altitude control signals, and via radio, sends them to the aircraft every few seconds.

•

LOGIC CIRCUITS made by RCA's Princeton, N.J., Labs for integrated devices have a component density of 10^8 logic elements per cubic foot. The devices use directly coupled unipolar transistors. These, claims RCA, are much more adaptable to integration than the more conventional bipolar types.

FIRST UNIT of advanced AN/APS-80 airborne search radar produced by Texas Instruments for Navy BuAer was delivered in seven months. Its first operational job will be in the anti-sub Martin P5M. The 400-lb set's parabolic dish is tilt-stabilized and can be operated in continuous rotation or in sector scan mode.

Self-contained Doppler for moon and planet landings studied by GPL

DOPPLER RADAR will definitely find uses in spacecraft guidance, General Precision Lab assured SPACE/AERONAUTICS on the strength of its studies of self-contained Doppler in such areas as lunar and planetary landing. GPL says it's also been studying the possibility of using "natural sources of electromagnetic radiation for vehicle velocity measurement."

•

NORTH AMERICAN picked Sperry's proposal among 10 bids for the advanced stable platform that will serve as the basic flight reference in the Mach-3 B-70 bomber. The contract may go to several million dollars, says NAA. It's a feather in Sperry's cap for its original twin-gyro platform using Rotorace (TM) gyros (see *AvAge, "Non-Floated Table Nears Inertial Accuracy," June 1958, p. 128*).

Extremely sensitive accelerometers will impart true inertial qualities to the original concept of forming the platform by setting two identical directional gyros at right angles to each other. The advanced system's accuracy reportedly will far outstrip the original design's—though even that could boast azimuth and vertical random drift rates of 0.25 deg/hr and 0.1 deg/min, respectively.

New designs extended range of new DEW radars

HEAVY ground radar sets were ordered from Bendix-Radio by USAF's Rome Air Development Center to be used for long range surveillance in an eastward extension of Canada's distant early warning (DEW) line. The $2.2 million contract, now nearing the production phase, required many new and advanced design techniques that give the equipment greater range than that of the present DEW line radars, the company states.

GULTON INDUSTRIES is producing crystal rate gyros under a government contract, the firm told SPACE/AERONAUTICS.

more on page 132

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PHYSICAL PROPERTIES far superior to those of glass are claimed for plastic replicas of precise optical components made by a molding process at Singer's Military Products Div., Bridgeport, Conn. In a trial run of plastic reflectors, the process reproduced a precision-ground glass mirror—of the type widely used in such infrared missile systems as the Sidewinder's—with great fidelity. Precise replicas have been made of a six-inch paraboloid mirror with a 5¼-in. focal length that concentrates 90 per cent of the incident collimated light within its 0.1-mm diameter.

Singer's process involves casting a negative from a precision-ground glass master and using it as a mold for casting the replicas. Both negative and finished replica are made of a special epoxy resin. The reflective surface is coated aluminum.

Terminal guidance for spacecraft to be studied by ITT Labs for ARDC

ARDC AWARDED a contract to ITT Labs in Ft. Wayne, Ind., for a study of an optimum terminal guidance system for spacecraft. Instrumenting the guidance, says D.M. Culler, head of ITT's Astrionics Lab, will involve sensing the ship's velocity vector relative to the body of destination, the altitude with respect to the velocity vector, and determining position in longitude and latitude.

•

COMMUNICATIONS experiments involving active repeaters in earth satellites have already started under ARPA sponsorship, according to Hugh L. Dryden, deputy administrator of NASA. In the near future, says Dryden, NASA will launch a 100-ft diameter plastic sphere, weighing about 75 lb, for use as a passive reflector of radio or radar waves for long range communications. These are but the first steps toward the expected goal of establishing world-wide communications systems, adds Dryden.

VOR-DME chosen over Decca for the next ten years

VOR-DME vs Decca short range navaid hassle was given a 10-year breathing spell, if not partly settled, at Montreal, Canada, meeting of International Civil Aviation Organization last month. A majority of members voted "yes" on three important proposals:

- to extend the life of VOR until Jan. 1, '75;
- to substitute a DMET spec for the 1000-mc DME spec;
- to use DMET whenever an ICAO regional meeting decides that a distance function is needed for either traffic control or navigation.

The last decision was hotly contested, for it forced a choice between VOR-DMET and Decca for the short range standard. The vote was 20 in favor of applying the DMET spec, four against, and 12 abstentions. Britain, backed up by Australia, Canada, and New Zealand, abstained.

Bid for Decca adoption seen as premature

MONTREAL DECISIONS still have to be ratified by the member nations and then by an ICAO council. In the process, the use of DMET might be downgraded to a mere recommended practice instead of a spec.

Many observers felt the British bid for Decca adoption was premature and would have had a better chance if postponed until '70. Major points against Decca are its complex instrumentation, unrealistic map display, LF operation, and unreliability.

Big feather in its cap was recommendation of President's (Curtiss) committee on air traffic control of an area coverage system. Many in U.S. apparently favor the area-coverage approach—but have been strangely silent since the report was made.

SAD FACT IN U.S.-BRITISH navaid relations is the technical dishonesty on both sides. Advocates of certain systems become so attached to these that they lose all objectivity and in effect suppress evidence—those facts that might detract from their claims.

U.S. sold Britain a VOR bill of goods in '56—largely on the strength of its claim that there would be little or no site error. Since then, site error has proved the Achilles' heel of VOR. "Experts" in U.S. also talk glibly about Decca's drawbacks, but the system actually never has had a fair trial here.

Britain, on the other hand, has shown only the bright side of the Decca coin. It has consistently played down the system's many defects, which might render it useless for the very difficult job it allegedly will do.

•

MICROMODULE CIRCUITS are available in sample lots to designers of military electronic equipment from RCA's Semiconductor & Materials Div., Sommerville, N.J. Initially RCA is making available engineering samples of 15 micromodules. Prices run from $46.60 for a 4.3-mc mixer to $247.30 for a binary divider consisting of two modules.

Want temperature-stable overcurrent protection?

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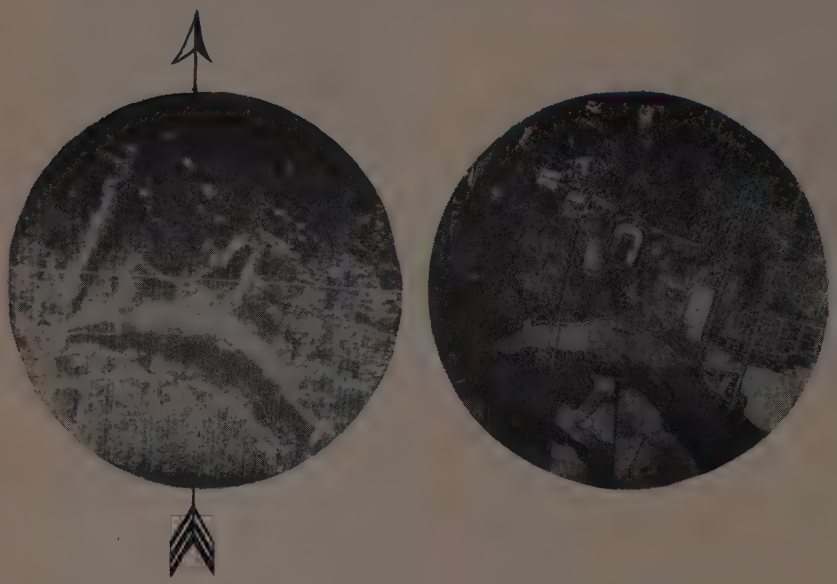


RADAR MAP of Princeton, N.J., from approximately 3000 ft altitude shows striking resemblance to photo of same area from same altitude (right). Note clarity of lake and football stadium (near center of radar map). The radar used was a high resolution 35 kmc set developed by RCA Research Labs for the Marine Corps. Purpose of the system is presumed to be spotting personnel and small targets from the air. The radar has an electrical gate that makes it possible to limit the display to targets between certain slant ranges.

Millimeter waves:

future depends on component development

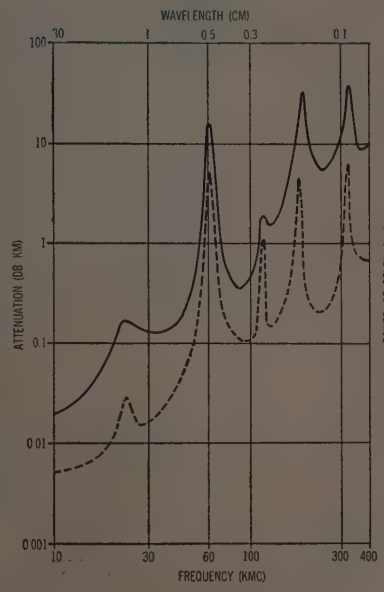
Vast in extent and virtually untapped, the millimeter region could be one answer to our acute need for more bandwidth. It looks especially good for space systems. However, wider use of this part of the spectrum depends squarely on component development — particularly on coherent generators.

by James Holahan, Electronics Editor

THE MILLIMETER PORTION of the electromagnetic spectrum—between 10 and one mm wavelength (30 and 300 kmc)—has long intrigued radiation researchers. They are particularly attracted by the extent of the band—bandwidth is nine times as large here as in the 0.01-mc-to-30-kmc area, to which practically all our RF work is confined.

Now that we have entered the space age, "milliwaves" look even more intriguing. Precipitation, water vapor, and oxygen attenuation (*Fig. 1*) has relegated MM waves to highly specialized uses in the atmosphere. In space, there will be no such attenuation problem—MM waves will be able to compete on an even footing with all other frequencies. In fact, they have the advantage over the more widely used bands that they permit high antenna gain with only small radiators. This alone could ease many of the design problems in space vehicles.

Because applications have been so scarce, there has been very little in the way of MM component devel-



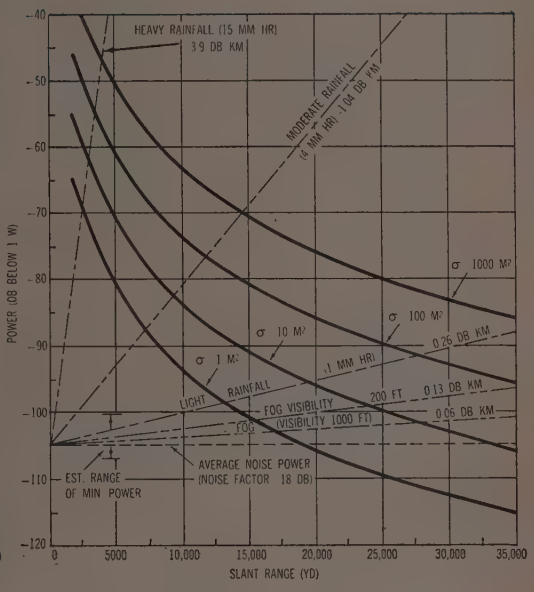
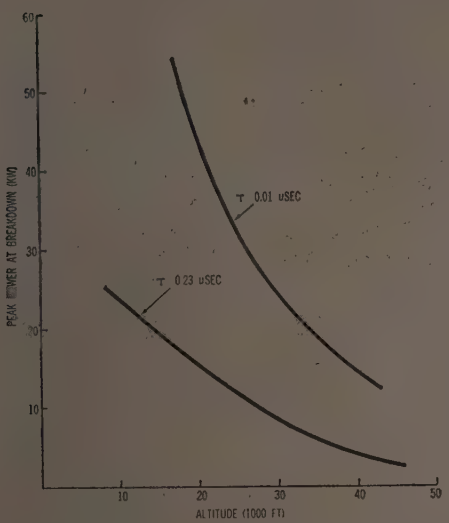


FIGURE 1: Attenuation in millimeter region caused by combined effects of water vapor and oxygen (left). Curves were calculated from measurements taken at 0.25 km elevation, 293 deg K, and 7.5 g/m³ water vapor (solid curve) and four km elevation, 273 deg K, and one g/m³ water vapor (dashed). Right: Rainfall and fog effects on maximum range at 35 kmc. Appropriate rainfall or fog line intersection with chosen target area (σ) curve gives range.



Observed Slant Range (yd)

Ground painting	8000—10,000
Sea return (New York harbor)	8000—9000
Airport runways	8000—10,000
Individual aircraft	10,000
Trucks on highway	< 11,000
Individual dwellings	10,000—11,000
City areas	18,000—20,000

WAVEGUIDE BREAKDOWN average plots taken by RCA Labs for several different RG-96/U waveguide pieces, including a matched E-plane corner, a bend, and a flexible length. Two or three times as much peak power can be transmitted at the shorter pulsewidth. Reason is that it takes a certain amount of time to ionize gas in a waveguide. (Frequency is 35 kmc.)

opment in comparision with even some of the least-used microwave bands. Production components are available—from only a limited number of sources and in limited quantities—for the 30-40-kmc window and at certain frequencies up to 75 kmc. At low MM wavelengths (below four mm) components are hand-made by research groups.

Coherent generators represent the crucial lack in MM design. Both high and low power types—especially the former being more vital. Up to now the assault on the MM region has, quite naturally, been launched from the microwave end with scaled-down magnetrons, klystrons, and backward-wave oscillators (BWOs).

Unfortunately, such conventional tubes have their limits when it comes to operating at super-high frequencies. According to J. R. Pierce, of Bell Labs, they suffer from four distinct weaknesses: (1) small size and precise physical tolerances, (2) heat dissipation, (3) circuit losses, and (4) cathode starting current densities.

Because of these "immutables", researchers claim the lower wavelength for conventional self-excited oscillator tubes to be around 2-3 mm. The answer to low MM generation, they believe lies in completely new approaches. Two seem to offer good possibilities.

One of these is the use of solid-state devices, such as

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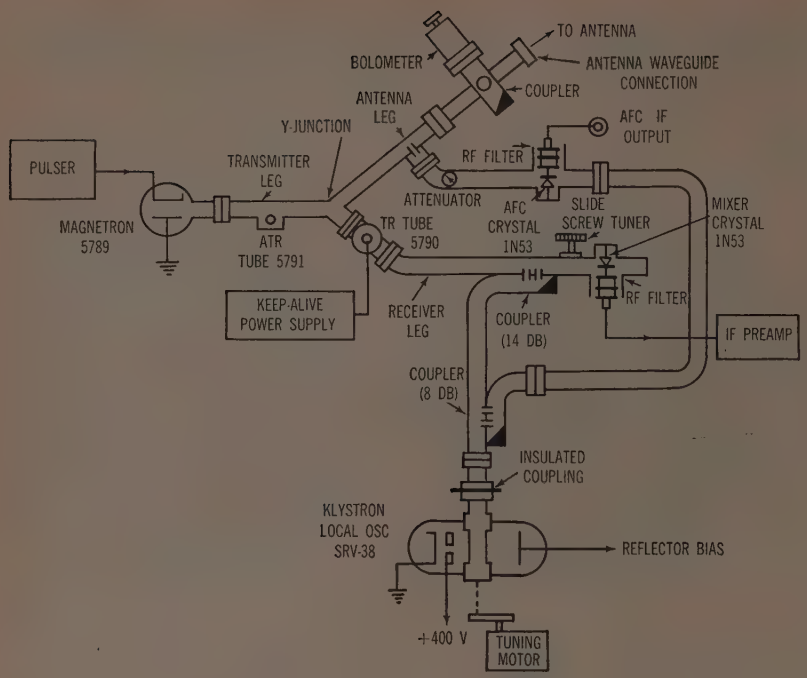


FIGURE 2: RF head of 35 kmc high resolution radar developed by RCA Labs, for BuAer. Unit mounts next to a Foster scanning antenna. Ferrites were considered for duplexer but were found to act like a non-ionized tube at very narrow pulsewidths. Hence a gaseous duplexer was used.

quantum mechanical generators (e.g., the maser) or ferromagnetic parametric amplifiers. (Microwave Engineering Labs, at Palo Alto, Calif., recently reported it has generated 50 W peak power at two mm by extracting this harmonic from a ferrite parametric amplifier excited with four mm.)

Though their efficiencies are very low compared with those of electron beam devices, quantum devices produce a very clean coherent signal. Many believe that they could be made to produce power in the kilowatt range with larger area active elements.

The other promising tack is to use harmonics generated in magnetrons and klystrons. Columbia U. researchers have had some success with second-harmonic generation in magnetrons. The second harmonic, they report, gives a fairly high efficiency power transfer, but efficiency is low at higher harmonics. Harmonic generation would eliminate need for extremely small size tubes at MM frequencies.

There are five unclassified high power generators known to SPACE/AERONAUTICS, all magnetrons working between 8.7 and 8.5 mm:

- type 5789 (Sylvania and Microwave Assoc.)—40 kw peak, 0.0008 maximum duty cycle, 0.1-1 usec pulsewidth, 200 hours estimated life;
- type 6799 (Sylvania)—120 kw, 0.00035 maximum duty cycle, 0.1-1 usec pulsewidth;
- type 4063 (Sylvania)—20 kw peak, 0.0005 maximum duty cycle, 0.1-1 usec pulsewidth (ruggedized);
- type 4155 (Sylvania and Microwave Assoc.)— 40 kw peak, 0.0005 maximum duty cycle, 0.1-1 usec pulsewidth (ruggedized);
- type 4064 (Sylvania)—70 kw peak, 0.0005 maximum duty cycle, 0.1-0.8 usec pulsewidth (ruggedized).

In the course of its research, Columbia University believes, it has developed a technique for building magnetrons down to three mm. It has also made a "very experimental" 2.6-mm magnetron with an efficiency of only one per cent and a life of several hours.

As small signal sources, several klystrons and BWOs are available commercially for isolated spots in the 30-60-kmc range. Power outputs range from a few milliwatts to a watt. Only one commercially available klystron works above 60 kmc—Amperex' DX151, a 100-mw tube that operates around 70 kmc.

An experimental BWO developed at Bell labs is believed to be the highest frequency self excited oscillator. Using a slotted periodic structure, it operates on 200 kmc, putting out a few milliwatts.

Another important component in the MM field is a 55-kmc traveling-wave power amplifier in development at Bell Labs. Experimental versions have given CW outputs from 125 to 200 mw, with a 19 db gain at maximum output and a low level gain of 25 db. Bandwidth is 10 kmc. Because of the tube's construction, cathode current is held to about one amp/cm^2—to permit cathode lifetimes of thousands of hours claims Bell.

Two other TWTs for the MM region are made by Sylvania: type PM 1779, a metal-ceramic, 60-75-kmc, one-milliwatt-minimum-output, and type PM1757, a 26.5-41-kmc, three-milliwatt-minimum-output tube. A number of military contractors are buying these tubes for classified uses.

In aircraft and missile electronics, there are relatively few known operating systems. One is a Q-band taxi radar (operating around 36 kmc) built by Decca for use at the London airport. This is actually a modified harbor radar. For landing aircraft and recoverable missiles, Bell Aircraft has developed a 34-kmc precision tracking radar.

A recently declassified 35-kmc high resolution recon radar developed by RCA Labs, Princeton, N.J., for the Marine Corps shows well what can be done with MM waves. Surface and airborne versions have been built that are similar to each other (*Fig. 2*).

High resolution was needed to discriminate against

Resolution Measurements

Targets	Range (Yd)	Ground-speed (Knots)	Resolution		
			Azimuth		Range (ft)
			Feet	Milli-radians	
Equal	560 yards	0	11	6.5	11
10 db different	560	0	12	7.1	13
Equal	6,500	0	96	5	
10 db different	6,500	100			15
10 db different	6,500	350			20

PULSE RESOLUTION measurements on RCA's radar. A crystal video receiver and separate transmitting and receiving antennas were used. PRF was two kilocycles. The crystal detector operated as a square-law device and was followed by chain of distributed amplifiers giving overall video bandwith of 100-110 megacycles. The amplifiers fed a high intensity 5RP11 cathode ray tube. The return is from three corner reflectors. Azimuth and range resolution data (Table) were gotten—at two ranges with two equal-size targets and with two targets differing by 10 decibels in the echoing area—by noting the spacing between two corner reflectors when they were distinguishable as two signals on a kinescope display.

ground clutter and to define target contours. According to Harry Kihn, RCA research engineer, high azimuth resolutions are achieved by using the highest practical frequency and largest feasible antenna. Beam- and pulse-widths are made as narrow as possible, so that small targets of interest tend to fill the beam. In this way, very little extraneous background is illuminated and terrain features and objects stand out. The narrow beam- and pulse-widths also cut specular reflection from rain, a rough problem with X- and K-band systems.

RCA Labs is working on more advanced but classified high resolution systems for the military.

MM waves could be used for Doppler

MM waves could also be used for very sensitive Doppler speed sensors. Here their advantage is that even a very small velocity change would give a large frequency shift. This characteristic appears especially useful for helicopter hovering and landing.

Development of a waveguide communication system using MM waves in the 55-kmc area is well underway at Bell Labs. The milliwaves would be piped through an 0.6-in.-diameter circular waveguide buried underground. Transmission would be in the TE_{01} mode, in which attenuation decreases with frequency and is negligible in the MM range, since there are only minute currents in the waveguide walls.

Secure communications appears as another important application of MM waves that is getting at least some attention from certain military contractors. Here a peak—rather than a valley—in the oxygen-water vapor attenuation curve might be chosen for the operating point.

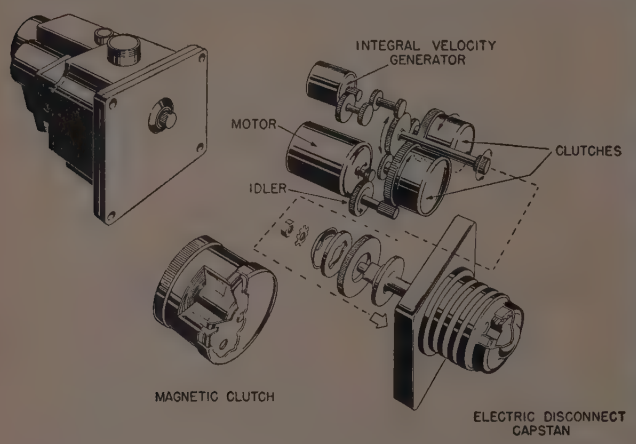
Scientific uses of MM waves might give the development of this region the biggest push. In many advanced experiments, such as thermonuclear reactions, MM waves are the key tools for diagnosis.

But the best chances for wide use of milliwaves appear to be in space—for communications, tracking, and recon. Whether or not milliwaves will win out over competing VHF, UHF, and microwave frequencies depends squarely on the development of high power generators.

While it's obvious that MM waves allow the use of smaller antennas for sharper beams, since antenna gain quadruples with each octave increase and a constant dish size, this advantage must be offset against the loss in power output with the decrease in the size of conventional generators—the power output of these generators drops about 6-10 db per octave.—End

High Resolution Radar Characteristics

Type of operation	Small-area reconnaissance and scrutiny
Operating frequency	34,860 mc (8.62 m) nominal, limits 34,512-35,208 mc
Scanning antenna	
Type	Foster
Azimuth beam width (at —3 db)	0.36 deg (6.3 millirads)
Vertical beam width (at —3 db)	1.9 deg (33.2 millirads)
Azimuth scan rate	12-30 per second
Azimuth scan sector	29 deg
Scanner figure of merit	2420 beamwidths per second
Gain	43.6 db
Transmitter-receiver	
RF pulse width (at —3 db)	10 millimicrosec
Transmitter peak power	30-40 kw
Pulse repetition rates	6,000-17,000 per second (equivalent to 27,000-9500 yd)
IF bandwidth	120-130 mc
IF center frequency	170 mc
Video bandwidth	75 mc
Receiver noise factor	16-19 db
Receiver IF noise factor	5.5-6 db
Range-antenna-depression-unit limits	
Minimum mid-range	3500 yd
Maximum mid-range	
X1 scale	11,000 yd
X2 scale	22,000 yd
Ground speed	100-350 knots
Altitudes above terrain	0-6000 ft



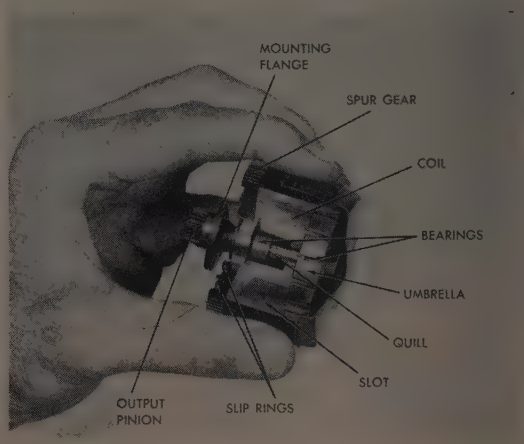


FIGURE 1: Exploded view (left) of magnetic clutch servo. Right: Internal details of a Lear dry-powder magnetic clutch. Centrifugal force distributes the magnetic powder evenly around the gap.

Magnetic clutches

add muscle to electronic servos

Limited response has been restricting the electronic servo in airborne control applications. This article shows how designers can overcome this drawback by using dry-powder magnetic clutches—which extend the lightweight electronic servo, with its sharp null zone control, long shelf life, and other advantages, to ranges up to about ½ hp.

by Dunstan Graham,
Systems Manager, Astronics Div., Lear, Inc.*

FOR ITS relatively small size and weight, the dry-powder magnetic clutch servo is capable of very high power amplification and rapid response. It is, therefore, a most useful component in the hands of autopilot system engineers. It not only simplifies requirements for electronic amplifiers and power supplies but also makes a special hydraulic power supply and distribution system unnecessary.

Typically, clutch servos can be driven by miniature tubes or transistors. For instance, you find that it takes less than a watt of input power to control 100 W at the output.

The rapid response of the magnetic clutch servo is itself useful, since it allows exceptionally high closed-loop control. In control system technology, "high gain" means positioning accuracy despite dead zone, dry friction, preload, and other troublesome non-linearities.

Though magnetic clutch servos come in a wide variety of shapes, sizes, and power ratings, and with

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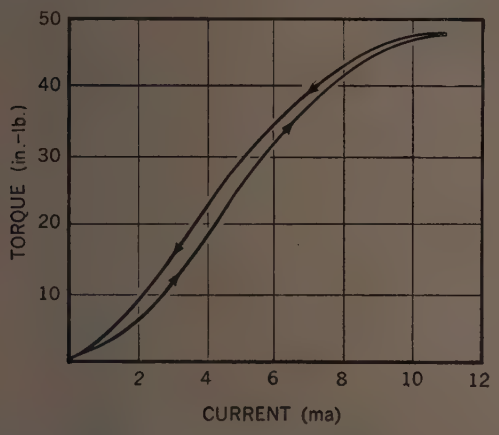

FIGURE 2: Torque-vs-current plot for single dry-powder magnetic clutch showing hysteresis.

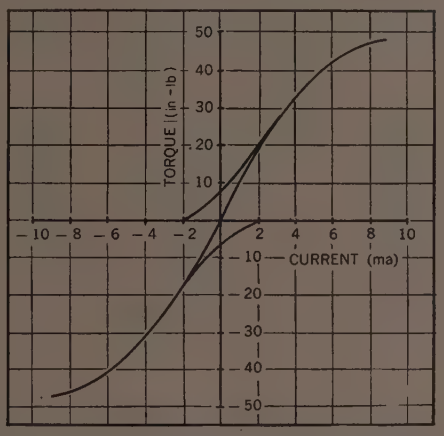

FIGURE 3: Biased operation of pair of clutches. Net torque is linearly proportional to differential current.

either linear or rotary outputs, they all have common design features *(Fig. 1)*. The motor (dc or ac, or any other prime mover, for that matter) drives the clutch housings through spur gears mounted on the periphery of each clutch. These gears are meshed so that the clutches contrarotate. Both clutch pinions mesh with the reach gear connected to the servo output pinion.

When one clutch is energized, the servo pinion rotates in a corresponding direction. Energizing the other clutch reverses the servo output. Because the main elements of rotary inertia lie in the motor and clutch housings, which always have a single direction of rotation, you can reverse the servo output very rapidly. In fact, the rotating motor and clutch housings form a reservoir of kinetic energy that can be tapped by energizing one of the clutches so as to accelerate the load with a lag determined almost entirely by the inertia of the load itself.

Most current clutch servos integrally mount a velocity generator, or tachometer transducer. Driven by the reach gear, it provides a signal proportional to the servo output velocity, stabilizing the closed servo loop at high gain. In some applications, an output position transducer or follow-up is also mounted on the servo, but it's usually best to mount it remotely.

Slotted "umbrella" ups torque

In the Lear dry-powder magnetic clutch *(Fig. 1)*, the massive iron core contains the coil winding (embedded in potting compound). Control current for the clutch reaches the coil through slip rings on the rotating housing. Centrifugal force distributes the magnetic powder evenly around the gap. Starting the clutches causes the magnetic particles to form linked chains across the gap, completing the flux path set up in the ferromagnetic core.

If there is any discrepancy between the rotating speeds of the housing and of the drive disk, or "umbrella," the particle chains shear. The torque transmitted from the continuously rotating housing to the output is proportional to the coil current over a wide range of input currents. It is always applied to the output smoothly and without chatter. Since the torque that is produced depends on overcoming only magnetic attraction, there is no detectable "wear" in the powder or umbrella even after several thousand hours of operation.

Experiments show that cutting slots in the umbrella increases the clutch's maximum torque capability. The umbrella connects to the output pinion by a shaft, or "quill," passing through the powder seal and a pair of bearings. To support the clutch in the servo, the rotating mass of the clutch housing is cantilevered from the mounting flange. Using these design techniques, Lear has produced clutches as small as one inch and as large as seven inches in diameter.

The operation of the dry-powder magnetic clutch servo is highly non-linear. For mathematic analysis and synthesis of magnetic clutch servos, however, you can set up a linearized model.

Figure 2 plots torque output vs input current for a single clutch. The characteristic nonlinear curve is avoided by operating the clutches in pairs with a bias current in each clutch. The curve for the combined characteristic *(Fig. 3)* shows that net torque is now linearly proportional to the differential current (the slope through zero being constant and high).

Hysteresis causes second order lag

The drag of the biased clutches eliminates any backlash between the clutch pinions and the reach gear on the servo pinion. Though the combined characteristic of the clutches still saturates on both ends, the operation of the servo is usually not affected. In the typical case it would represent a factor of safety.

In addition to the properties already discussed, the plot of output torque vs input current shows the effect

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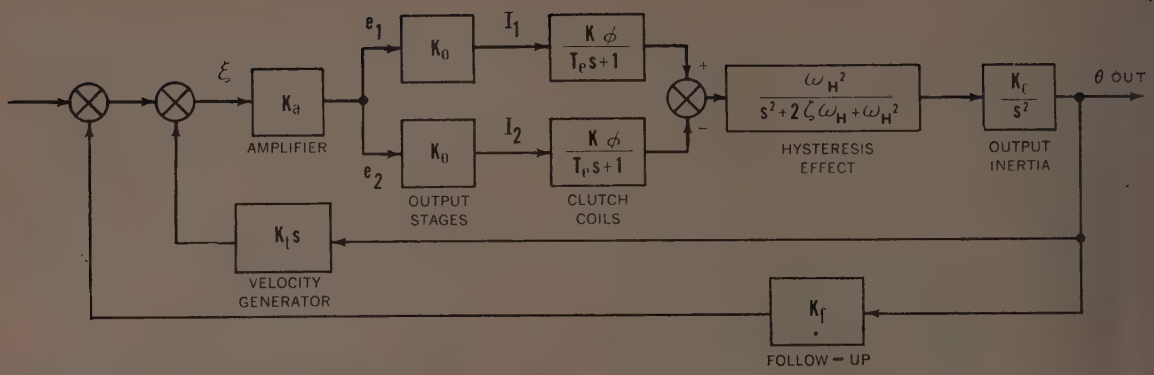
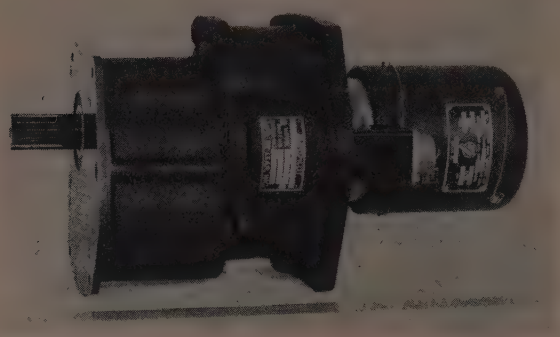
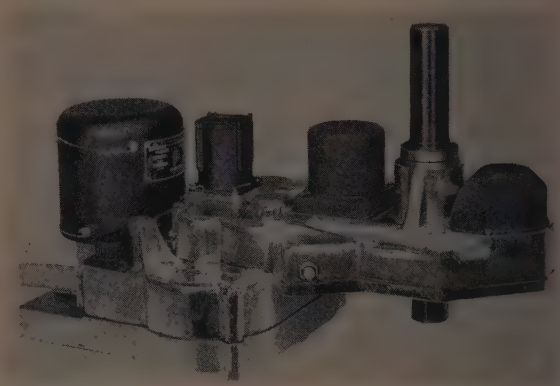


FIGURE 4: Closed-loop positioning servo.



AILERON SERVO DRIVE (Lear 2231) used on Lockheed X-7 ramjet test vehicle.



EXTREMELY FAST servo actuator (Lear 3050) used on Sergeant ballistic missile.

of magnetic hysteresis in the powder particles. With slowly varying sine-wave signals applied to the clutch, hysteresis contributes only a small phase lag (about 10 deg) without attenuating the torque output. At higher frequencies, the phase angle of the output lags progressively more, attenuating the output. We might characterize this effect as a second-order lag—except that, to account for the small initial phase angle, it must be added to the phase margin.

The parameters of the clutch transfer function itself depend largely on the gap width and on the amount of powder used. Too much or too little powder degrades the clutch's performance. Typical values for the two time constants in the second-order lag are 1.5×10^{-3} and 5.0×10^{-3} seconds.

Figure 5 shows the torque-speed characteristic of a Lear clutch servo. Inherent damping is, by conventional definitions, nearly zero. It's noticeable only in the slight downward slope of the curve from the initial point of maximum torque. For each value of differential input current, nearly maximum torque is applied until the limiting velocity is reached. There the accelerating torque vanishes quite abruptly. In this respect, the clutch servo behaves much more like a hydraulic servo than an ac or dc motor servo.

Because the inherent damping of the servo is negligible, you must supplement it by feeding back a signal from a velocity generator in order to operate the servo in a closed loop. AC and dc tachometer generators perform this function equally well. However, it's important that as much care as possible be taken to prevent any backlash in the gear train driving the velocity generator.

Other means of both parallel and series compensation, such as lagged clutch-current feedback and error rate damping, can be used in servo loops for aircraft control surface positioning. With velocity feedback, again, you can operate the servo as an integrator or velocity servo, but it's far more common to feed back output position, as well, so that the servo becomes a positioning device.

Remote pot for position feedback

Usually, a remotely mounted potentiometer or synchro transducer serves as the follow-up, or position feedback, element. This lets you to put a maximum number of resiliences, dead zones, frictions, etc., within the automatic control loop in such a way that their effects are made harmless.

The servo output is usually geared down to reduce speed and increase torque. In a typical installation, 0.2 deg of follow-up rotation will command half the saturated torque of the servo.

Gear reduction is often achieved by means of a spring-loaded capstan *(Fig. 1)*. This unit disengages the servo from the control system, except when 28 V dc is applied to it. It contributes less than two inch ounces of residual torque to the cable controls. Its backlash, as that of other gear reduction devices, must be minimized to get the best performance out of the position control.

The velocity generator and follow-up signals, together with the input signal, are mixed in an amplifier that delivers control current to the clutches. The amplifier must be as lag-free as possible and act as an ideal current source. If the current source is not "stiff", you get a time lag in the current buildup in the clutch coil.

If pentodes with high plate resistance are used to drive the coils, the transfer function from voltage input to coil current does not attenuate until the device has reached 100 cps. Actually, the clutch coil's inductance seems to decrease with increasing input frequency. On the other hand, if your amplifier is made up of transistors or triodes, clutch-current feedback improves the performance of the amplifier as a current source.

Higher gain improves accuracy

Figure 4 shows a closed-loop clutch-positioning servo. Its output positioning accuracy is limited by the available feedback gain. The higher the gain, the better the accuracy. Effective gain is limited only by considerations of dynamic stability. Since the time lag in all elements of the control loop can be kept very small, the gain can be very high.

Frequency response is commonly taken as a measure of gain. Typical values for the first corner frequency of Lear clutch servos range from 7 to 20 cps. Experimental units have been produced with a flat frequency response beyond 60 cps.

Early magnetic powder clutches ran into reliability problems. Clutch "freezing" (because the powder compacted into a solid mass) and powder leaks were common complaints. Progress in powder development and in perfecting the seals overcame these troubles.

Autopilot servos' MTF is 7750 hr

A reliability survey of 2800 autopilots (Lear F-5s and MB-2s in F-84Fs and F-86Ds) disclosed a total of 185 servo failures in about 478,000 hours. Since each autopilot has three clutch servos, this means that the mean time to failure (MTF) for a servo is (478,000x3)/185, or 7750 hours.

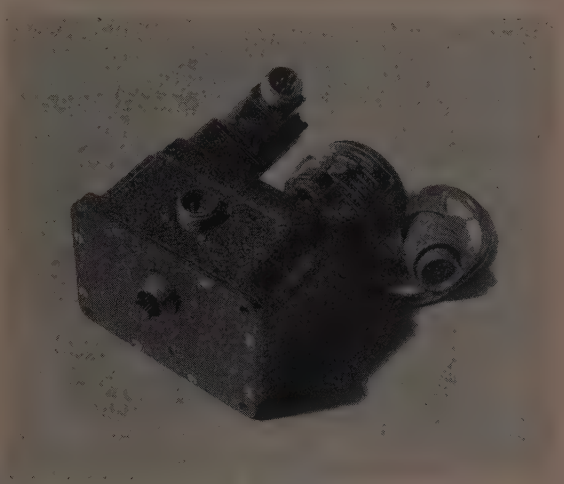
Each servo, in turn, has two clutches, and only 93 of all failures were attributed to clutches. So the MTF of a single clutch is (478,000x3x2)/93, or 30,800 hours. We can take this figure to be representative of the MTF of other airborne electromechanical components, such as motors and gear trains. The survey results do not, however, make routine preventive maintenance of clutches any less important. In fact, it's recommended that, in airborne installations, the clutches be replaced about every 5000 hours.

The shelf life of dry-powder magnetic clutch servos has no known limit. Servos stored for over three years worked faultlessly on being placed in service.

Magnetic clutch servos typically are used as autopilot servos in fixed wing aircraft, drones, and helicopters with both boosted and unboosted controls. Also, they can be used most effectively as remote positioning devices for engine test cells and for making fuel trim adjustments in ships on the flight line. For industrial applications, 60-cycle units are available.

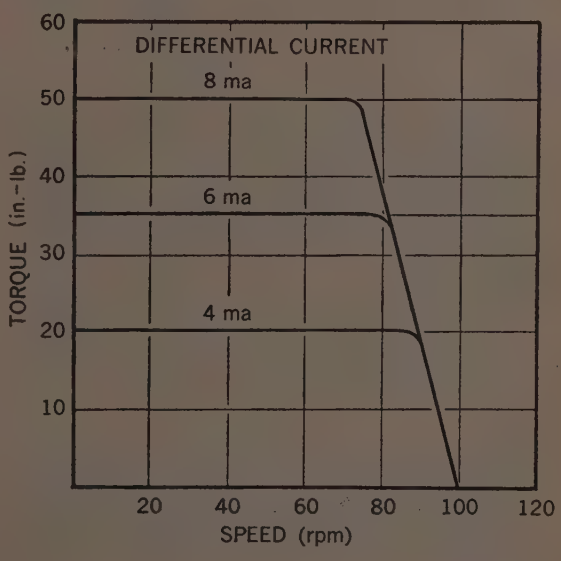
One of the most powerful clutch servos ever designed is used to drive the ailerons of Lockheed's supersonic X-7 ramjet test vehicle. One of the fastest is used to drive the control surfaces and jet deflectors on JPL's Sergeant ballistic missile.

The dry-powder clutch has already proven its ability to meet varying control system needs, both on the ground and in the air. Its development has kept abreast of the state of the control art over a decade of explosive change. Since its inherent features—high power amplification, sharp null zone control, small size and weight, and minimum time lags—would seem to be almost fundamental to both air and space vehicle control system design, a safe future seems to be assured for this servo.—End



TYPICAL dry-powder magnetic clutch servo for use in autopilots.

FIGURE 5: Torque speed characteristic for various differential currents.



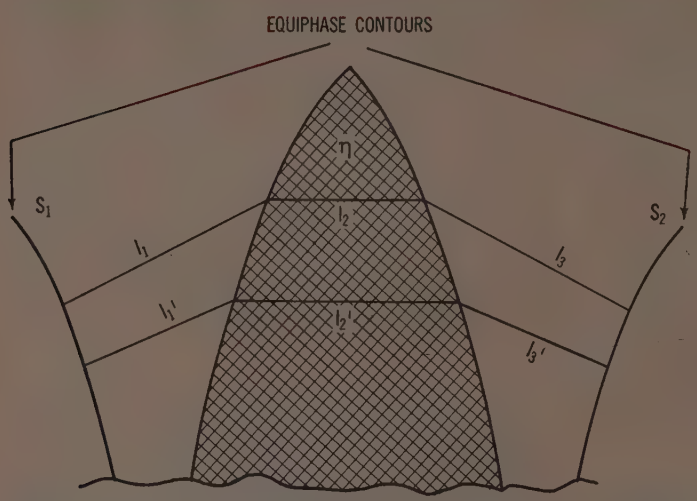


FIGURE 1: Double-surface lens shows general design principle of equalization of optical path lengths.

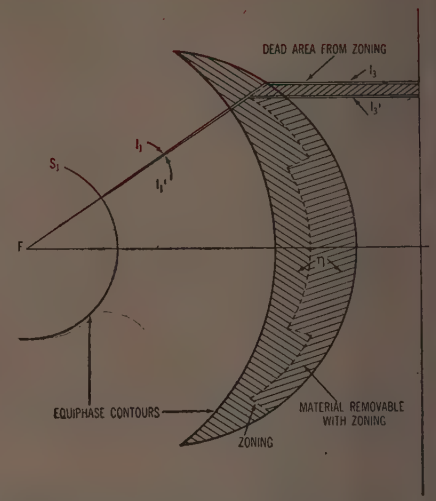


FIGURE 2: Dielectric lens with one surface that is an equiphase surface of the incident wave.

When you can use

microwave lenses

When should you pick a lens antenna over a reflector type, and which lens should you choose? These questions, so important to today's radar engineers, are answered in this comprehensive review of lens antenna designs.

by R. W. Martin and W. M. Yarnell

Surface Armament Div., Sperry Gyroscope Co.*

IN THE microwave region, R-F energy takes on some of the characteristics usually associated with optics. This has helped us to speed up the development of radar. The similarities between microwave radiation and visible light spectrum radiation let us use simple optical analysis in developing many types of microwave lenses and antennas.

In radar antenna design, a microwave lens obviously should never be used when a simpler, cheaper reflector will do the job. But its weight and complexity become acceptable when it can replace several reflector antennas or, naturally, when there is no other way to meet the specs.

The microwave lens is a see-through device. This is one of its big advantages for antenna design—the primary feed, no matter how large or complex, won't interfere with the focused beam. It is like the optical lens in that energy from a wide beam primary source, such as a waveguide horn, is focused into a beam whose shape may be controlled for the needs of the radar system. Through the lens, energy may be refracted, undergo phase delay, or advance; or there may be any combination of such phenomena.

Any microwave lens will have either a constrained or an unconstrained medium. We can further subdivide

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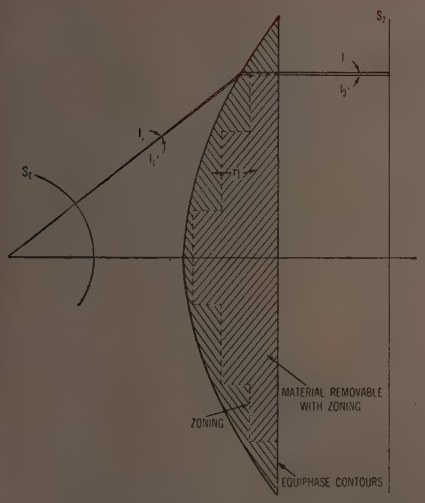

FIGURE 3: Dielectric lens with one surface that is an equiphase surface of the emergent wave.

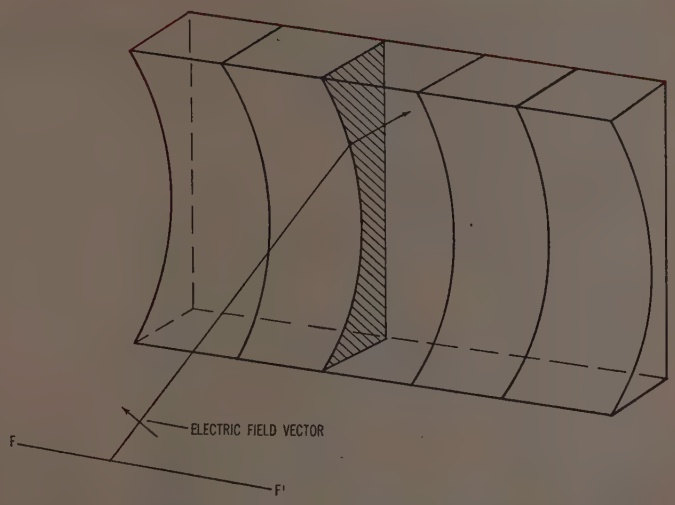

FIGURE 4: Single constrained metal plate lens with electric vector, lens plates perpendicular to cylinder axis.

lenses according to the constant or variable index of refraction of their medium.

In a dielectric, or unconstrained lens, rays are refracted at the interfaces between the dielectric and air. The ray path is predicted by Snell's law of optics.

In a constrained medium, the ray's path is restricted in one or all planes by metallic boundaries. Snell's law doesn't, in general, describe the change in ray direction at the lens surface. Strict adherence to Snell's law therefore shows whether a medium is constrained or not.

Lens design, or "ray tracing," is based on two general principles of geometrical optics: (1) the equality of optical paths along rays between pairs of wavefronts and (2) Snell's law of refraction. In a homogeneous medium, the rays are straightline segments. In a medium with a variable index of refraction, the path may be an infinite set of arcs or segmented straight lines.

In vacuum, the optical path length is simply the length of the ray segment. In any medium, it is the physical distance times the refractive index (η, defined here as free space wavelength divided by wavelength in the medium).

In a dielectric medium, η equals $\sqrt{K_e}$ where K_e is the relative dielectric constant. In a constrained medium, the wavelengths within the boundaries of the lens are controlled by the physical parameters of the medium's metallic sub-boundaries. Dielectric material may or may not be present.

Must check with Snell's law

To avoid confusion, let us define dielectric, as a material that has uniform electric properties and acts as a homogenous medium. K_e may have practical values from near unity to about 15. The higher values are obtained by loading relatively low dielectric constant homogenous materials, such as isocyanate foams and Teflon, with titanium dioxide or some other filler.

A design approach using the principle of equal optical path lengths (*Fig. 1*) must be compatible with a solution using Snell's law. The "ray tracing" method consists of determining the lens surfaces so that the combined optical length ($l_1 + \eta\, l_2 + l_3$) along any one ray between two equiphase surfaces (S_1) and (S_2) on opposite sides of the lens is the same as the electric length ($l_1' + \eta\, l_2' + l_3'$) along any other ray between S_1 and S_2.

Simple dielectric lenses are divided according to the number of refracting surfaces. If one surface is an equiphase surface of the incident wave (*Fig. 2*) or the emergent wave (*Fig. 3*)—so that the waves are normal to this surface and pass through unrefracted—we get a "one-surface" lens. This type of lens is relatively easy to design. The lens in *Figure 1*, on the other hand, is a "two-surface" lens.

"Zoning" reduces bulk and weight

The dielectric lens may become heavy and bulky. To avoid this, we can "zone" it—by reducing the optical path length of a group of rays in the lens medium by an amount equal to the path length increase outside the lens. *Figure 2* shows a possible zoning design. In the case of this type of lens, zoning creates a "dead area," or shadow region. This reduces lens efficiency and causes aberrations that tend to distort the secondary beam in space.

In *Figure 3*, zoning doesn't cause dead areas and becomes a distinct advantage. However, when the frequency is changed, zoning introduces a new error in lens performance that is analagous to chromatic aberration in optical lenses.

Dielectric lenses are used mostly when small size is needed, weight is secondary, standard molding and machining can cut cost, and the frequency is so high that

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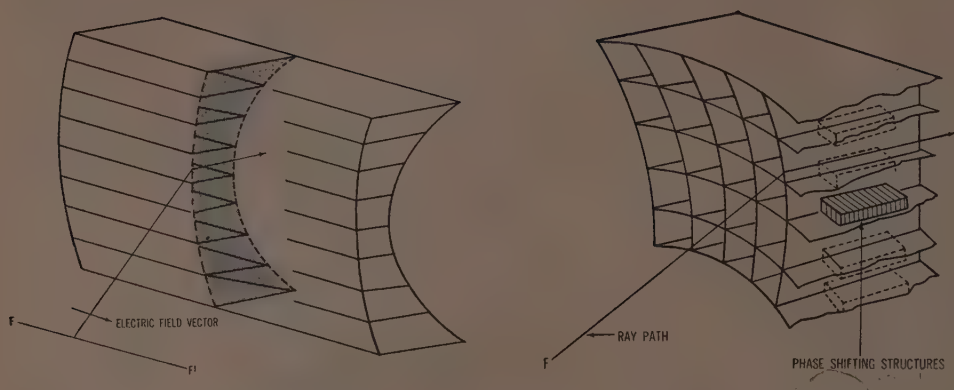

FIGURE 5: Single constrained metal plate lens (left) with constraint in a plane perpendicular to the cylinder axis. Right: Doubly constrained metal plate lens.

other lens media are ruled out by their complexity and tolerances. Such an application might involve a missile guidance antenna where an aerodynamic surface is completed by a radome that also serves as a lens.

Dielectric lenses have two weaknesses:

- Most dielectric materials absorb some RF energy and convert it to heat.
- There is considerable reflection of power at the lens surfaces. This effect may be offset to some extent by proper surface matching—which in itself is not a loss-free procedure, however.

Lens structures have been developed in which the lens medium consists of plates parallel to the electric field vector and accurately positioned by non-reflecting spaces. The wavelength in the medium is (for an air-filled region):

$$\lambda_M = \lambda / \sqrt{1 - (\lambda a 12a)^2},$$

where a is the spacing and λ the free-space wavelength. The index of refraction for such a medium always is less than unity.

The direction of propagation in the lens must be parallel to the plate surfaces. Therefore, Snell's law doesn't describe the direction a ray takes at the lens surfaces. With cylindrical lenses, this doesn't change the lens design essentially. In *Figure 4*, electric vector and lens plates are perpendicular to the cylinder axis, and Snell's law is valid. That the lens is constrained in a dimension parallel to the cylinder doesn't enter into the analysis.

Simple analysis for "egg crate"

In *Figure 5*, the constraint is in a plane perpendicular to the axis of the cylinder. No focusing action takes place in the plane of the line of source (cylinder axis). The condition of constraint replaces Snell's law in the other plane. The principle of equal optical path lengths describes this lens completely. Both these comparatively simple lenses are two-dimensional—the feed source (FF^2) dictates the beam shape in the plane containing the line source feed, and the lens focuses only in one plane.

The parallel-plate spherical lens, however, is three-dimensional. The feed source here is a point. This type of lens has been used more in radar systems than the less versatile cylindrical metal plate lenses.

A widely used lens is the double-constrained, or "egg crate," type (*Fig. 5*). Since the constraint is complete, the analysis is simple. It is based entirely on the equalization of optical path lengths.

This lens essentially is a stack of waveguides. Any method used in waveguide design to advance or retard the phase of the ray also applies to the individual cells of this lens.

The doubly constrained lens may be considered as a superposition of two lenses. The polarizations of the component lenses are orthogonal to one another. This means a dual-polarization lens may be designed for two feed systems (so long as these are polarized orthogonal to one another), so that two types of radar directing activities can go on at the same time.

The constrained lenses we have discussed are subject to the same rules of zoning as the dielectric lenses. The reflection of energy from the surfaces is again present (but different in nature). As we will see, this effect can be reduced by well-established surface matching techniques.

Plastic found better than metal

Metal plate lenses are light and rigid. However, it has been found that metallized plastic egg crate lenses can be made with closer tolerances and higher power handling capacity than all-metal lenses. They also show lower unit cost and production time.

When the refractive index is variable, a whole new world of lens design opens up. The combination of the variable surface shape with a variable index makes scanning lenses with very wide ranges of beam scan quite feasible.

In the well-known Luneberg lens, for instance, the dielectric constant is varied along the radius of a sphere from 2 at the center to unity at the sphere surface. In this lens, a system of rays forming a flat phase front and approaching the sphere from any direction is focused to a point at the opposite side of the sphere. There is also a cylindrical Luneberg lens, but its scanning is limited to one plane.

Varying the index of refraction of dielectric lenses is not easy. Some lenses use many concentric shells of slightly different dielectric constants to approximate a smooth transition. Others use foamed dielectrics of variable density as well as fillers. Quantitative control of these mediums is very difficult.

Another class of variable index unconstrained lenses uses the artificial dielectric properties of lattice arrays

of conductors whose size is a small fraction of a wavelength. This is the macroscopic analogy of the submicroscopic array of polar molecules in an actual dielectric. The density of the conducting obstacles per unit volume controls the index of refraction, which therefore can be varied throughout the lens volume.

Another class of lenses uses the waveguide properties of doubly constrained types. Slow-wave structures, such as are used in traveling-wave tubes, are placed in the cells. The designer has considerable control of the overall lens characteristic—by controlling the frequency characteristics of such phase delay structures, the lens can be made to operate over a much broader band of frequencies than is otherwise possible.

Focusing differs for "modes"

If its medium has different and independent, but controllable, refractive indexes for two orthogonal polarizations, a lens may have different focusing characteristics for each of two polarization modes. Such mediums have been used in the doubly constrained lens discussed above to make it even more versatile.

By loading this lens, we can maintain common surfaces for both polarizations, yet keep the advantage of dual-mode operation. Common surfaces are especially good when the lens is covered with a contact radome.

Scanning lenses are primarily multiple-focal-point types. If a single-polarization lens can be made to focus perfectly to two points, it will also focus adequately to all points on some arc joining them. (The spherical Luneberg lens is the exception, having an infinity of focal points.)

Good scanning through 20 beamwidths

It can be shown that, if more than one focal point is to result in a lens, at least two variable parameters must be used in its design. The two used most commonly are lens thickness and index of refraction. Lenses with good performance when scanned through 20 beamwidths have been designed. With constrained media, such lenses have been successful over at least a 15 per cent band.

For surface matching to reduce power loss through reflection, a surface layer of dielectric can be used that corresponds to the quarter-wave transformer in a transmission line. Among the techniques devised for constrained lenses, one involves the staggering of lens cells. This reduces the reflections for the angles of incidence in the plane of the electric vector. In the plane of incidence perpendicular to this vector, reflections normally are small at the usual angles of incidence.

By controlling the width and height of the lens cells, reflections in both planes of incidence can be reduced. Also, dielectric or metallic matching transformers can be inserted in the ends of the cells.—End

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TERRIER SPQ-5 missile guidance radar, made by Sperry for shipboard installation, uses lens antenna. It has a novel time sharing arrangement that allows monopulse and guidance radar to work together. Both beams are focused through the lens.

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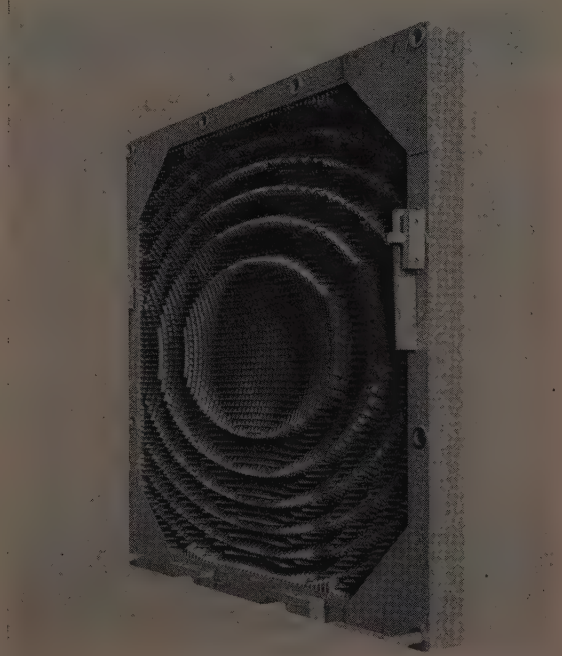
RELATIVELY LARGE doubly constrained lens. Similar lenses are being made at Sperry by molding six sections in metallized plastic.



Typical RCA Ceramic-Metal Power Tubes utilize
power design, and feature high-efficiency forced-air co

RCA Ceramic-Metal Power Tube

Known throughout industry and military services for high-efficiency operation and ability to withstand high voltages at ultra-high frequencies, RCA Ceramic-Metal Power Tubes are the answer for the designer who requires higher power in a smaller, compact tube design. No other power tubes in this class combine features such as: coaxial-electrode design; low-loss ceramic bushings between electrode contact surfaces; matrix-type cathode; extra-sturdy heater, low screen current, virtually no primary screen grid or control grid emission!

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Typical RCA Ceramic-Metal Power Tu

Type No.	CW Service max. Plate Input (Watts)	Pulse Service max. Peak Plate Input (Watts)	max. Frequency for full Input (MC)	Di
A-2582*	30	–	1215	
A-2587*	–	3750	1215	
6816	180	–	1215	
A-2543-A*	–	9000	1215	
A-2572*	1250	–	1215	
A-2585*	–	64000	1215	
7213	2500	–	1215	
A-2576-A*	–	180000	1215	
A-2545*	20000	–	400	
A-2581*	–	2000000	500	

*RCA Developmental Type—Available on Sampling

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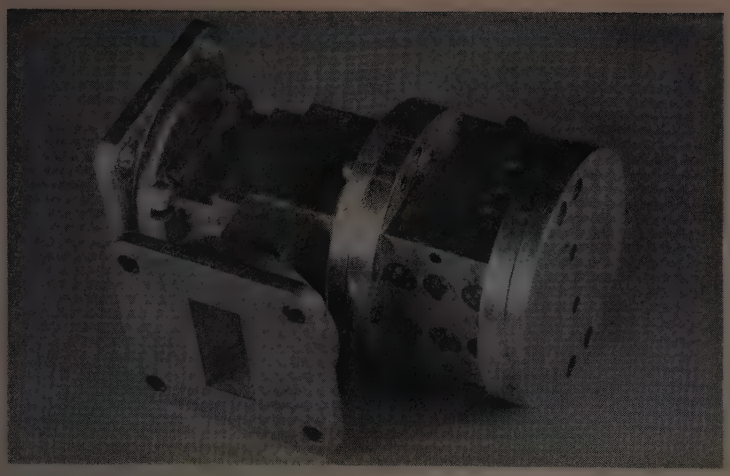
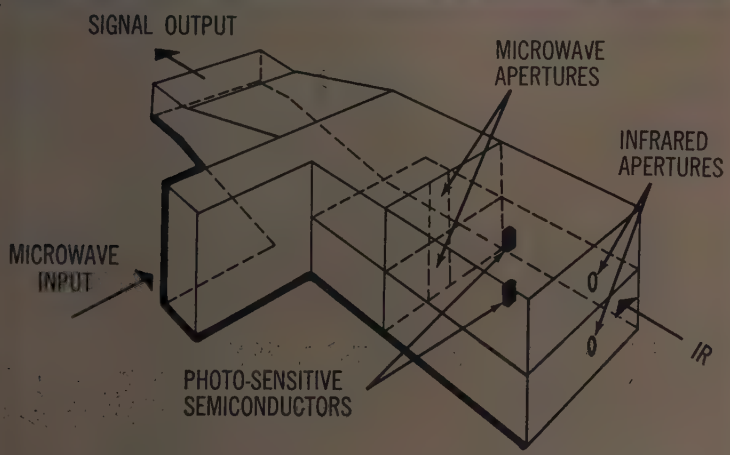
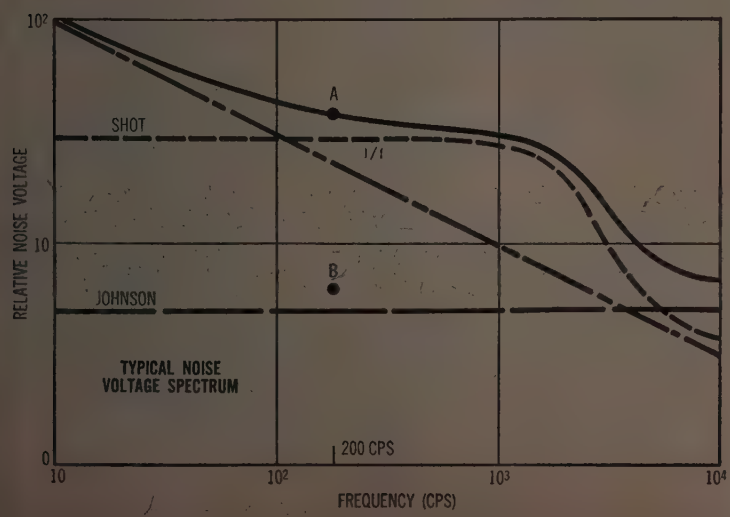




MICROWAVE (MW) energy is fed into waveguide "tee" (top) whose two colinear arms end in identical MW cavities holding photosensitive semiconductors. Signals reflected by the tuned cavities are combined 180 deg out of phase in the output arm. When system is balanced (reflected signals have same amplitude and are in phase), no power is coupled into output arm. With IR admitted into only one cavity, energized semiconductor alters phase and amplitude of that cavity's reflected signal, unbalancing system and producing an output signal. Graph compares total noise of conventional detectors (A) with that expected of GB's device (B). Better S/N and wider bandwidth will allow use of IR in areas now bypassed because of IR detector noise limits.



design digest

by Bernard Kovit
Associate Electronics Editor

Microwave IR detector has high S/N, broad BW

INFRARED detector developed by GB Electronics, a subsidiary of General Bronze Corp., 711 Stewart Ave., Garden City, N. Y., combines microwave concepts with IR sensing elements to get sensitivity that may exceed by several orders of magnitude that of existing devices. Lab model reportedly attained higher S/N than conventional voltage-biased or PEM detection cells. Basic element of device is a photo-sensitive semiconductor simultaneously energized by microwave and incident IR radiation. Variations in the complex dielectric constant of the semiconductor material are sensed as impedance changes of two high-Q microwave cavities operating at resonance in a balanced bridge setup. Inherently higher S/N is mainly the result of: (1) absence of dc bias and associated electric contacts to semiconductor and (2) "noiseless" electronic amplification through high-Q cavities. Larger bandwidth makes device highly suitable for high resolution reconnaissance and mapping. Write in No. 57 on Reader-Service Card for more data.

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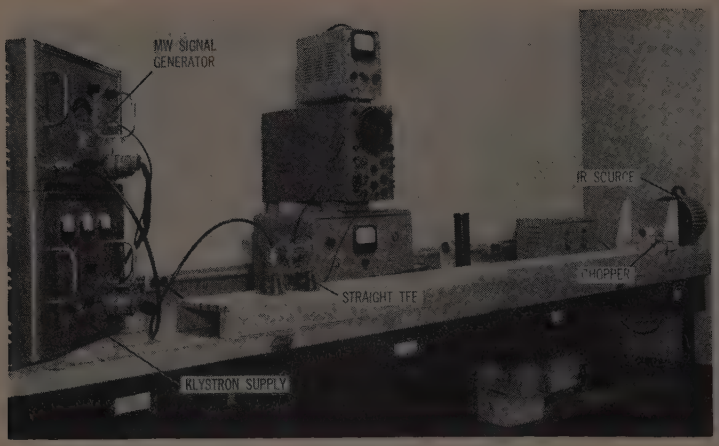
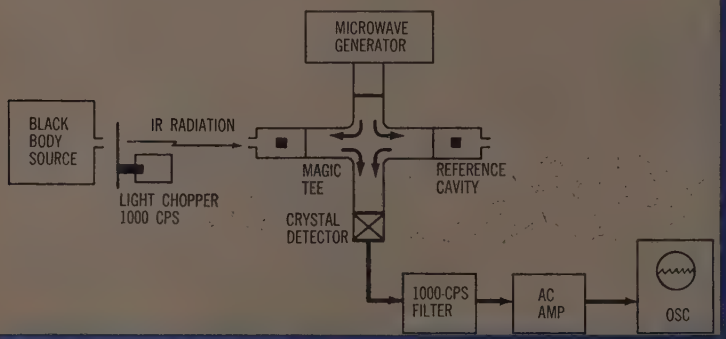
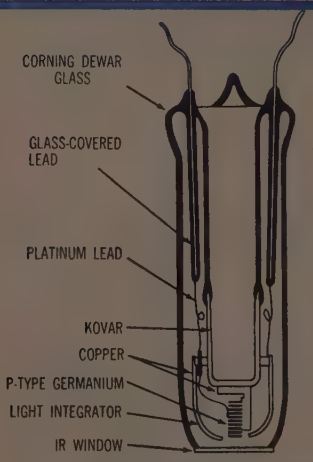
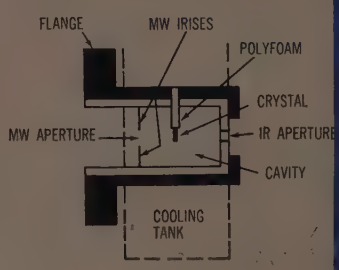


LAB SETUP (cooling tanks removed) has IR source, chopper, and detector spaced on calibrated optical bench. For test, both cavities are tuned to same resonant frequency (while dark, cooled, and with crystal in). Then MW generator is set at cavity resonance. Results with crude setup, says GB, are very promising: NEP is on the order of 5×10^{-10} W for S/N of 1 and bandwidth of one cps centered at 960 cps. Better-matched cavities and crystals, HF heterodyning, and use of Invar material should cut NEP further.





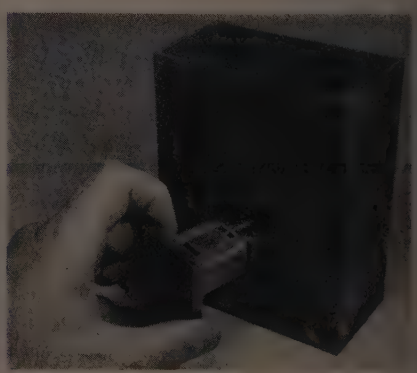


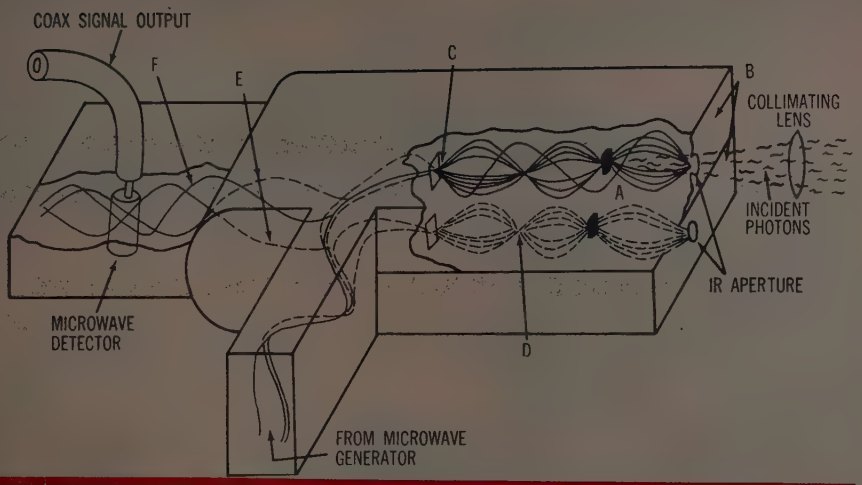
DESIGN COMPARISON—Typical photodetector (left) depends on copper conduction for cooling. MW device puts crystal in what amounts to virtually a cold oven (completely surrounded with coolant). Light integrator in conventional design is a copper shield; in MW device, whole interior of cavity is silver-plated to act as reflector. No electric contacts give MW device a noise advantage. High-Q cavity is 1½ in. long, ½ in. high. MW flange is standard 1¼x1¼ in. Crystal is of gold-doped germanium, cavity of brass.

PERFORMANCE FACTORS

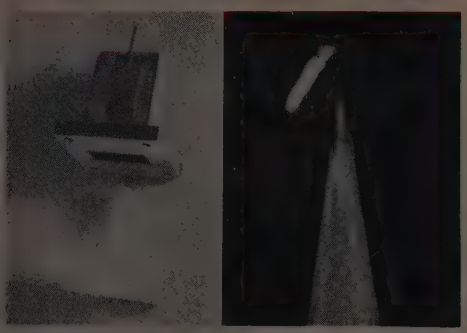
- **Crystal material:** gold-doped germanium
- **Crystal size:** 0.030×0.030×0.060 in.
- **Sensitivity:** NEP, 5×10^{-10} W, should go to about 5×10^{-12} with planned improvements (conventional detectors have NEP of about 10^{-9}); use of idium antimonide will improve sensitivity to longer wavelengths
- **Bandwidth:** 1-2 mc (conventional detectors run about 200 cps, NEP for larger bandwidths being degraded by factor of $\sqrt{\Delta F}$.)
- **Special response:** useful detection to 6 μ
- **Operating temperature:** liquid N_2, or −320.4 deg F (77.3 deg K)
- **Optical system:** conventional

HARDWARE—Straight magic tee (top); cavity, with polyfoam post holding IR crystal and set with slide, cut flush at surface, and cemented (above); cavity cooling method (below).





FUNCTIONAL — (A) IR crystals, (B) cavities, (C) MW apertures, (D) high cavity Q amplifies effect, (E) reflected waves from dark cavity, (F) reflected waves from illuminated cavity have different phase and amplitude, thus don't cancel with reflected waves from dark cavity.

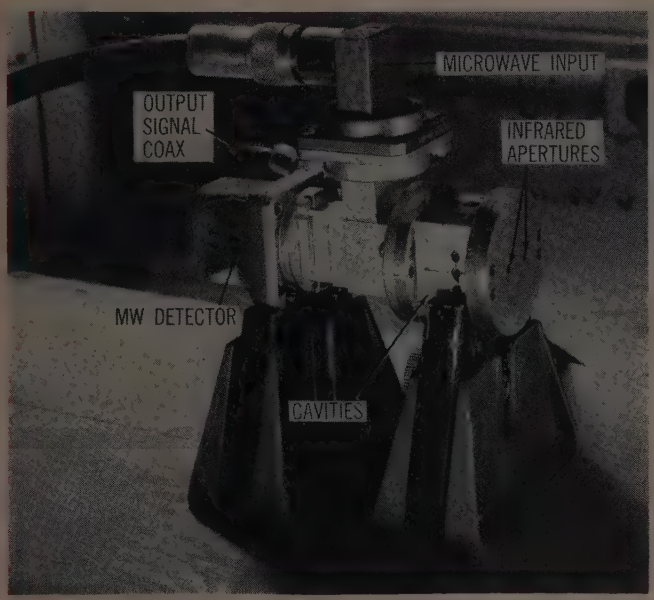


CRITICAL positioning of tiny crystal was aided by grooved guide. Properly positioned, the illuminated crystal markedly lowers Q, while increasing VSWR, at both ambient and liquid N_2 temperatures. Cooling makes it less conductive than at ambient by depressing its free carriers from conductive to valence bands. Now the generation of free carriers in crystal by the incident illumination has a bigger effect.

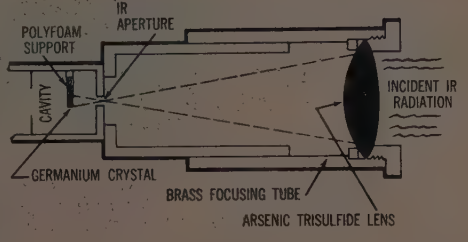
•

SOURCE of IR illumination is 600-deg C maximum black body (Barnes RS-3A). Hysteresis synchronous motor operates chopper at 960 cps.

ADVANCED DETECTOR—Hughes magic tee with cavities of Invar, whose low temperature coefficient of expansion keeps small temperature variations from cutting the device's sensitivity. Advantages: (1) Both IR ports are on one face, so IR input can be alternated to operate cavities push-pull and double the signal output; (2) the overall assembly is smaller and lighter. Planned use of indium antimonide crystals will eliminate the cooling tank.



IR OPTICS—Long-focal-length lens compensates for small entrance aperture's limit on IR reaching crystal. Background level is kept down as lens filters out light outside desired frequency band, focusing tube shuts out stray reflections.



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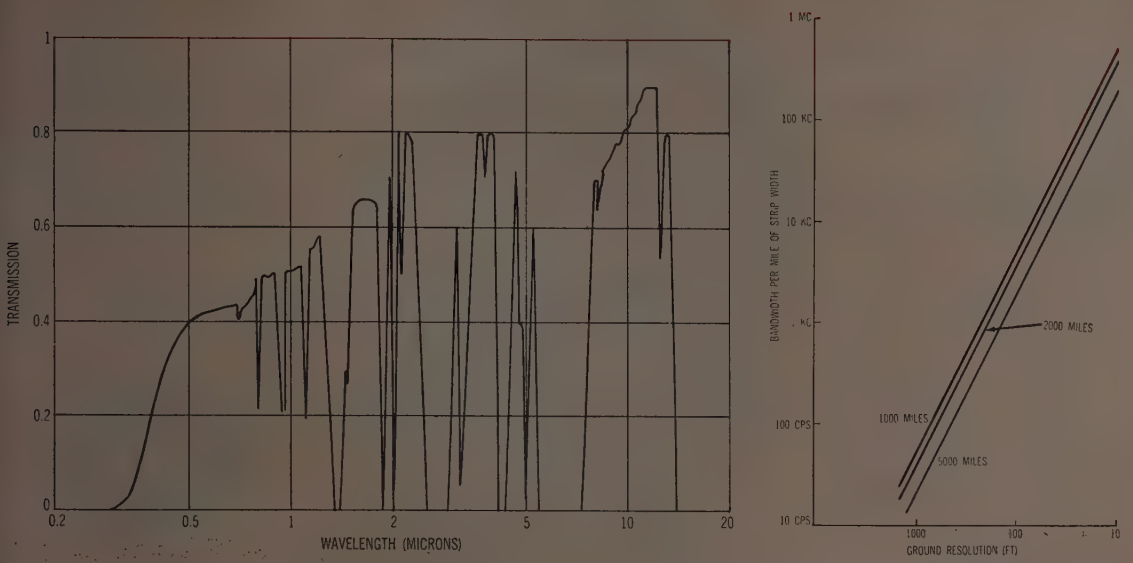

FIGURE 1: Average atmospheric transmission spectrum (left) for one atmosphere thickness and 13.6 mm of precipitable water vapor on a clear day. Right: Strip mapping needs (neglecting earth's rotation.)

Infrared detection from recon satellites

This is the second article of a two-part series on the possibilities of adapting satellites to detection and recon missions, as outlined in a detailed study made by a research group at Du Mont Labs.* The first article in this series appeared in March 1959 (p. 157).

THE most important component of artificial radiation probably is in the infrared (IR) range. Since temperatures approaching the sun are seldom found in artificial sources, the spectrum of artificial radiation is shifted toward IR, in accordnace with Wien's displacement law (*Table I*).

The intensity of radiation from artificial sources can be readily calculated from the radiation laws (*Table I*), if values are assigned to the size, temperature, and emissivity of the source. Typical of the wide range in the radiative characteristics of artificial sources is the fact that industrial smokestacks may show temperatures as high as several hundred degrees above ambient with emissivities near unity, while a large missile's exhaust may have a temperature of about 3000 deg K with an emissivity of perhaps 0.2.

Figure 1 shows the atmospheric transmission spectrum of both artificial and natural earth-surface radiation as it would be sensed from above the atmosphere. You find that the absorption of IR radiation occurs in wavelength bands separated by "windows" of negligible absorption.

It would be highly desirable to instrument a recon satellite for detection during the interval during which illumination from the sun is not available. Under these conditions, the only radiant energy available to a detector is the earth's self-emission, which appears (from beyond the atmosphere) to have a temperature of about 250 deg K. You would have to keep the detector from responding to IR emissions from the atmosphere itself, whose constituents would

more on page 153

*Space Reconnaissance Laboratory Research & Development Div., Allen B. Du Mont Laboratories, Inc., 750 Bloomfield Ave., Clifton, N.J.

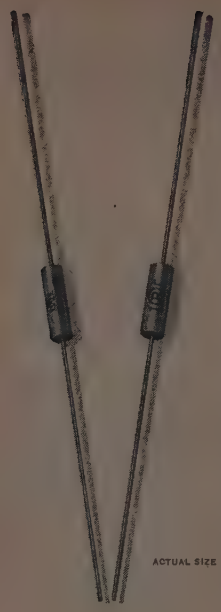

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Table I: Radiation Laws

The Stephan-Boltzmann Law gives the total radiation from an object as:

$$W = \epsilon\sigma T^4,$$

where W is total radiation (in W/cm^2); σ, 5.672×10^{-12} W/deg^4; T, source's temperature (in degrees K); and ϵ, emissivity factor.

Wien's Displacement Law gives the maximum radiation wavelength (λ) at any specified temperature as:

$$\lambda = 2960/T,$$

where T is in degrees K and λ is in microns. Wien derived a corollary law stating that the maximum radiation is proportional to the fifth power of its absolute temperature, or:

$$W_m = KT^5.$$

Planck's Equation gives the radiation emitted by a black body as a function of wavelength:

$$J = C_1\lambda^{-5}(e^{C_2/\lambda T} - 1)^{-1},$$

where J is radiant power at wavelength λ in (W/m^2/micron); C_1, $3.735 \times 10_8$; and C_2, 1.438×10^4.

veil the earth's surface, and so reduce contrast.

A preliminary calculation of power available at the altitude of the satellite implies that detection will be limited by the internal noise of the detector.

Though emissivity differences may significantly affect contrast, we shall examine it here only in terms of detectable differences in temperature. Consider two resolvable elements, each of area A cm^2, with one at the apparent earth temperature of 250 deg K and the other at a slightly higher temperature (250 + δ deg K) and with combined emissivities equal to ϵ. The power (P_1) emitted by A_1 may be expressed as:

$$P_1 = A\,\epsilon\,\sigma\,250^4,$$

where σ equals 5.67×10^{-12} W/cm^2 deg^4, and the power emitted by A_2 is:

$$P_2 = A\,\epsilon\,\sigma\,(250 + \delta)^4.$$

Expanding P_2/P_1, you get:

$$P_2/P_1 = 1 + 4\,\delta/250 + 6(\delta/250)^2 + 4(\delta/250)^3 + (\delta/250)^4.$$

For reconnaissance, we're interested in those cases in which $\delta/250$ is small (say, 0.01) and small error terms higher than the first power may be ignored, giving:

$$P_2 = P_1 + 4(\delta/250)P_1,$$

more on next page

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and the excess power in P_2 over P_1 is:

$$P_2 - P_1 = 4(\delta/250)P_1.$$

A case of interest is that of reconnaissance from an altitude (L) of 300 miles (4.83×10^7 cm), probably the minimum orbiting altitude. The power (R_1, in watts) received at an aperture of area A cm² from P_1 will be:

$$R_1 = P_1L/\pi L^2 = AL\ \epsilon\ \sigma\ 250^4/\pi(4.83\times10^7)^2.$$

At a wavelength acceptance range of the dectector of 1.8 microns (lead sulfide with germanium filter), about 5×10^{-4} times R_1 would be effectively detected as a signal (S_1, in watts), or:

$$S_1 = 5\times10^{-4}\ AL\ \epsilon\ \sigma\ 250^4/\pi(4.83\times10^7)^2.$$

Only five parts in 10,000 of the available radiated power reaches the detector, because of atmospheric absorption, spectral mismatch of emitter and detector, and losses in the optics. Taking ϵ as unity and substituting constants, we get:

$$S_1 = 5\times10^{-4}\ 250^4\ 5.67\times10^{-12}/(4.83\times10^{-7})^2 = 1.51\times10^{-21}\ AL.$$

For a collecting aperture area of 3000 cm² (24 in. diameter), we get:

$$S_1 = 4.53\times10^{-18}\ AL.$$

The excess power from element A_2 must be detected in order to get contrast distinction between the two elements. So the useful signal becomes:

$$S_2 - S_1 = S_1(4/250) = 7.25\times10^{-20}\ A\ \delta\ watts.$$

You can readily determine the information rate of the IR mapping system without referring to any specific pickup method. This rate then defines given bandwidth requirements that depend only on the area to be mapped and the mapping speed.

In a single line of strip scan, you're covering 5280 W/r elements, where r is ground resolution (in feet) and W width of strip (in miles). This line must be scanned in an interval r/v, where v is the ground velocity of the vehicle. Since you can transmit n elements per second within a bandwidth of $n/2$ cps, the required bandwidth (Δf) is:

$$\Delta f = 2640Wv/r^2\ cps.$$

The bandwidth required per mile

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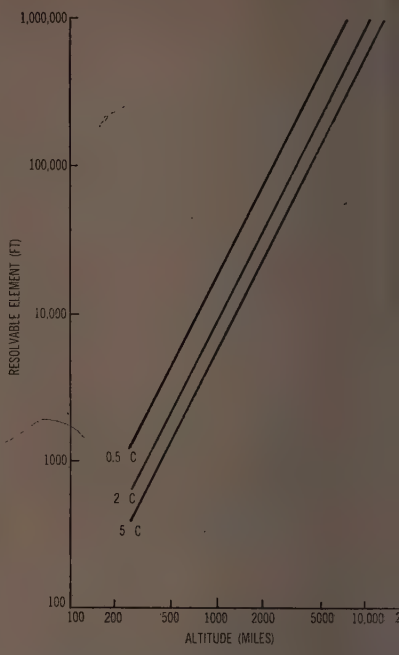
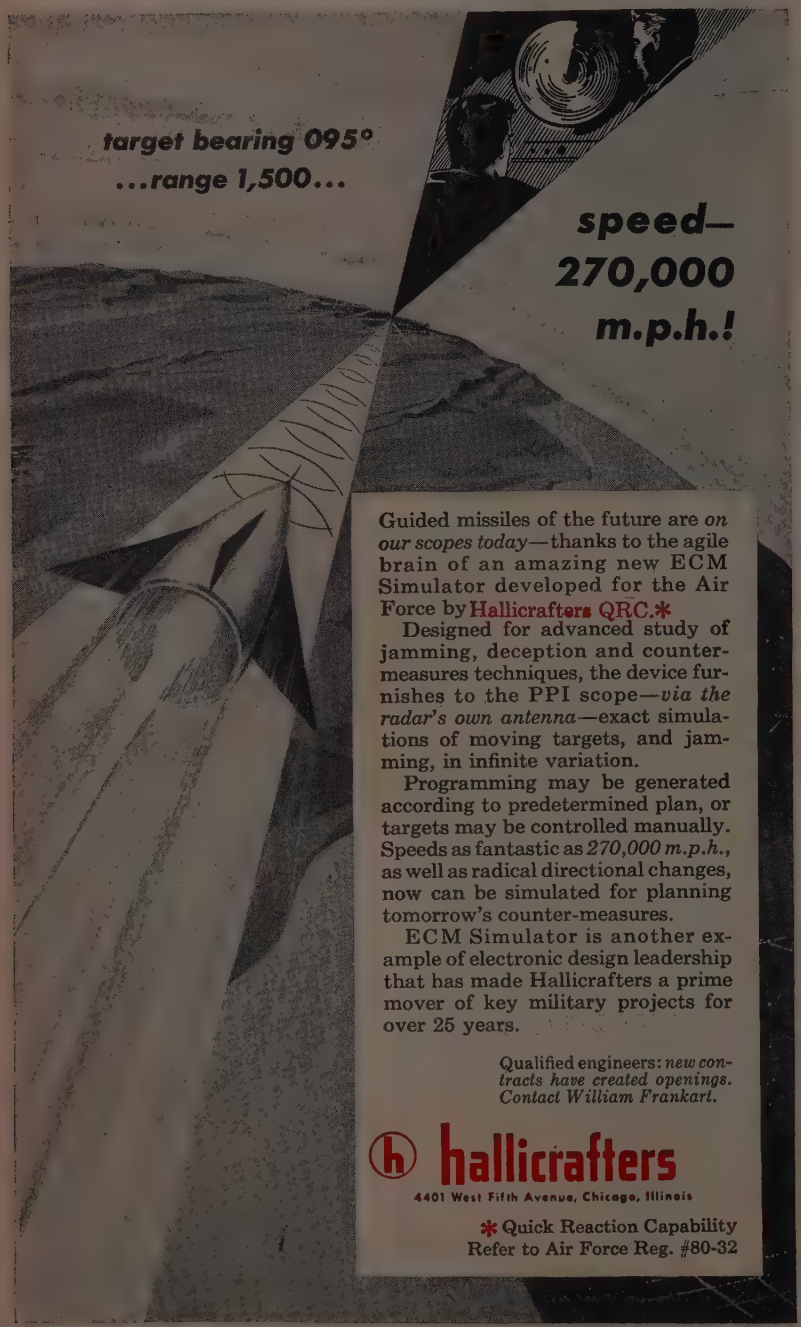


FIGURE 2: Resolution of an infrared satellite recon system.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At the request of U.S. Army Ordnance, the Jet Propulsion Laboratory now began to develop a long-range guided ballistic missile system, incorporating the proven, smooth-burning light-weight acid-aniline system. These achievements sparked the development of a whole series of rocket vehicles. In 1954, the Army accepted the JPL developed CORPORAL, which became America's first tactical guided ballistic missile system; its accuracy exceeded design requirements.

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Table II: Detectable Resolution*

Temperature (deg C)	Resolvable Element (ft)
0.5	1700
1.0	1220
2.0	850
5.0	535

*For assumed temperature differences of an object above its background.

of the strip is easily found, since one parameter is now eliminated from the expression. *Figure 1* shows the bandwidth required per mile of strip for various ground resolution values and altitudes. You can see, for instance, that mapping a 50-mile-wide strip from an altitude of 1,000 miles with a ground resolution of 1000 ft will require a bandwidth of 2.48 kc. For detection, the power difference S_2—S_1 must at least equal the equivalent noise input (NEP) of the detector, which may be in the range of 10^{-10} W for each element of a high-resolution, lead sulfide detector with a bandwidth on the order of 1000 cps.

An IR recon system's performance may be quite simply illustrated by tabulating the detectable resolution for an assumed temperature difference (δ) of an object above its background (*Table II*). By applying the inverse square law dependence of received power on distance, *Table II* may be extended to show a detectable resolution as a function of altitude and temperature difference (*Fig. 2*) for the assumed constants (in our case, a lead sulfide detector and 24-in.-diameter optics).—End

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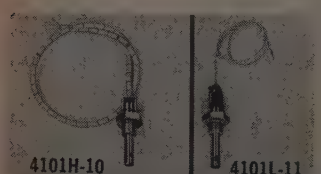

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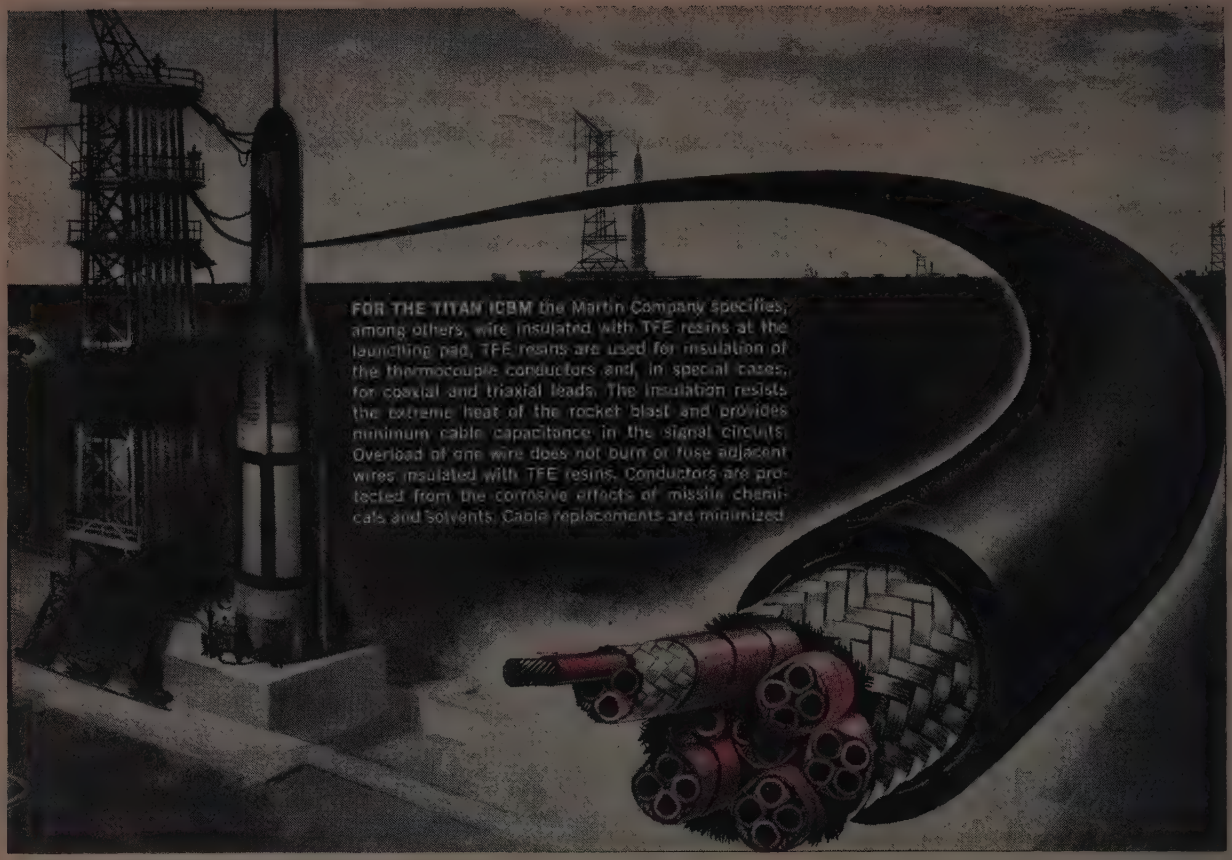

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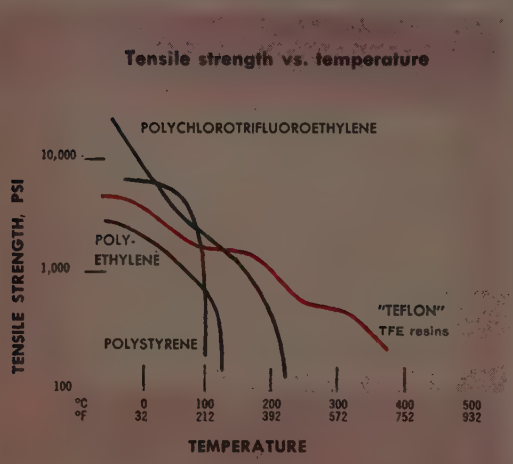

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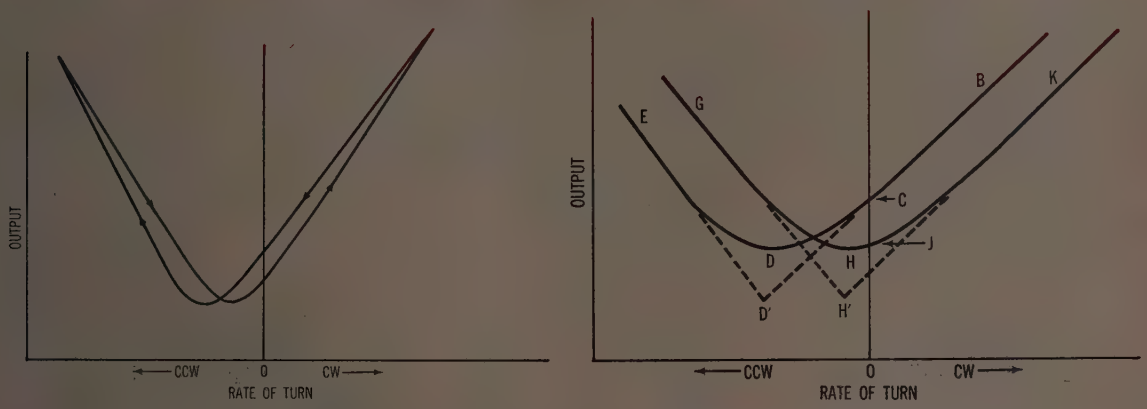

CALIBRATION CURVE (left) of rate gyro fed into hypothetical phase-insensitive Y-axis of X-y recorder, with signal equivalent to angular velocity fed into phase-sensitive X-axis. Right: Theoretical enlargement of null of graph at left. Electric nulls are at D and H. Zero calibration is the intersection of the curves.

Lax specs cause confusion in rate gyro field

Though testing methods in the end determine the performance criteria for rate gyros, they are seldom spelled out adequately in the systems engineer's spec to the gyro maker. Here, therefore, are some important tips on aspects of gyro design and testing that generally are not too well understood.

by Norbert W. Batterman, Project Engineer, R. C. Allen
Aircraft Instrument Div., R. C. Allen Business Machines, Inc.*

THE rate gyro is vastly misunderstood component. In the first place, many of the engineers specifying rate gyro characteristics for systems they are designing don't know enough about the unit to take full advantage of the state of the gyro art. Their most common failing is an inability to see the interrelationship between gyro design parameters (see *Table*).

Secondly, the lack of accepted terminology and test methods leads to misunderstandings between the engineer-buyer and the supplier. To make sure he will be getting what he wants—and also the best the art is able to supply—the systems engineer writing a rate gyro spec must.

- understand the limitations of the component;
- define all words and phrases that may not have universal meaning;
- know about testing procedures and call for the specific one he wants whenever several could be used but would give different results.

Let us review here some of the main areas of interpretation discrepancy. Since potentiometer and demodulated pickoffs are relatively better understood, only the ac-type microsyn pickoff will be discussed.

Electric Null—Imagine a rate gyro output fed into a non-sensitive Y-axis of an X-Y recorder, with a signal equivalent to angular velocity feeding the phase sensitive X-axis. The calibration curve would look like the one in the *Graphs*. (Hysteresis is exaggerated for explanatory reasons.)

The *Graphs* also show a theoretical enlargement of the null of the calibration curve. The minimum output value that this

more on page 161

*R. C. Allen Aircraft Instrument Div., R. C. Allen Business Machines, Inc., 333 Commerce Ave., S. W., Grand Rapids 2, Mich.

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Principal Rate Gyro Characteristics

Maximum Input Rate: $\omega = K\theta/H$,
where ω is input rate; K, spring rate of restraint; θ, gimbal deflection; and H, angular momentum about spin axis.

Undamped Natural Frequency: $f_n = 0.5\pi\sqrt{K/I_p}$,
where f_n is undamped natural frequency and I_p is moment of inertia of gyro motor about precession axis.

Allowable Gimbal Deflection due to angular acceleration: $\theta = \alpha I_p/K$,
where α is angular acceleration about precession axis.

Precession Torque: $T_p = H\omega/g_1$,
where T_p is resulting torque about precession axis and g is gravity.

curve indicates near null (points *D* or *H*) is the noise (non-responsive output) level, or, more commonly, the electric null (quadrature, harmonics and quiescence).

Zero calibration—the error allowable in setting the electric null at zero angular velocity—is represented by the intersection of lines *BCDE* and *GHJK* with respect to zero angular velocity input.

Because of the exaggerated hysteresis of the *Graphs,* zero calibration is hard to see. However, it can be said to be at the angular velocity rate at which the electric null is observed. The maximum value of output at zero angular velocity (point *C*) is the total null. This null includes electric null, friction, hysteresis, and zero calibration. (Sometimes total null is confused with electric null.)

The departure from true linearity of the sensitivity near null, as referenced to points *D* and *H*, denotes the phase angle variation near null. This sensitivity variation near null should be (but seldom is) stipulated in the spec.

If the curve at electric null is quite flat, the flatness is sometimes erroneously referred to as dead space. Actually dead space is due to free play in mechanical linkage in the reversing of motion. All rate gyro pickoffs are directly connected, thus an ac pickoff does not exhibit dead space as such.

Electric null is tested with a very low rate induced to the sensitive axis of the rate gyro until a minimum of output is observed (regardless of input direction) on a vacuum tube voltmeter. The output read is the electric null, and the angular velocity is the approximate zero calibration. True zero calibration is found at that rate of turn when zero output is observed on a phase sensitive meter and there is no hysteresis. The maximum total null is automatically observed in testing for hysteresis.

Hysteresis is the maximum difference of output taken at any specified rate of input when that input rate is approached from opposite directions. However, two major factors that must be considered:

- Friction must be included in measuring hysteresis. (Tapping out friction is a tainted procedure.)
- A rate gyro shows maximum hysteresis at null and can be most accurately measured at zero angular velocity. When measured at any value but null, the hysteresis read is approximately equal to the square root of the change of rate imposed with respect to the null hysteresis.

Hysteresis measured on a rate-of-turn table

Hysteresis is measured with the gyro placed on a rate-of-turn table and taken to the specified maximum input rate in either the clockwise or counterclockwise direction. The rate of turn is decreased to zero, and the direction is reversed to the maximum input rate. The table is then allowed to coast to a stop, while output and phase direction are recorded. This last operation is repeated in the opposite direction of rotation.

The total hysteresis is the algebraic difference of the clockwise and counterclockwise readings on a phase-sensitive voltmeter.

The percentage of hysteresis is half the algebraic difference times 100 divided by the full scale of output in one direction. For any given design:

per cent hysteresis $= CK^{2/3}\theta_{max}$,

more on next page

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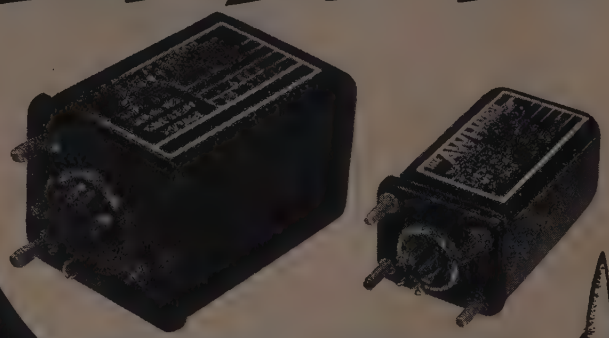

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where C is an arbitrary constant. We can see that the amount of gimbal deflection and natural frequency as a function of spring restraint determine the amount of hysteresis.

Hysteresis is not only proportional to the ratio of imposed fiber stress to ultimate stress expressed as a function of θ, but also parabolically proportional to the duration of the imposed stress and the time since relief of the imposed stress.

For a low-hysteresis unit it has been observed that the hysteresis recorded immediately after relief of imposed stress is twice the percentage of that recorded five minutes after the imposed stress has been relieved.

For this same type of unit, it was also noted, the duration of the imposed stress varied the percentage of hysteresis five times more after one minute of continuously imposed stress than after instantaneously imposed deflection. Hence it is particularly important to include in any spec the time during which the unit is exposed to angular velocity and the time after relief of this rate of turn. If these two times aren't specified, it could correctly be said that the hysteresis of this type of unit might be anywhere between 0.1 and 0.5 per cent.

Linearity is tested by using a calibration curve in a form similar to *Figure 1* and is plotted by input-output points, increasing and decreasing in both directions of angular velocity. The most common straight line for both clockwise and counterclockwise rotation then establishes the basic *gain* or *sensitivity*. The deviation from the straight line is the linearity.

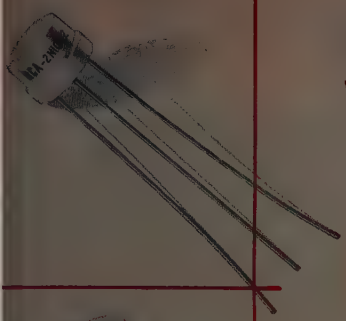
Several points should be noted about the gain slope:

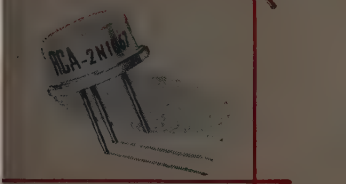
- Linearity tolerance should include hysteresis, friction, and resolution.
- Measuring instrument readability and accuracy become major factors in the linearity tolerance.
- The average calibration curve or gain slope does not pass through zero angular velocity but through the electric null.

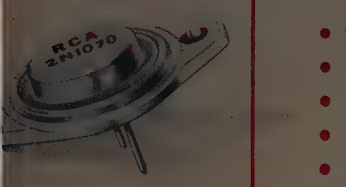
The inclusion or exclusion of hysteresis in the linearity tolerance must be noted in the spec to minimize "intepretations of convenience."

The *sensitivity band* does not include hysteresis and linearity

more on page 165







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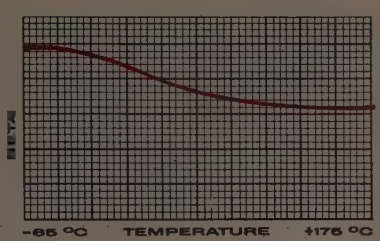

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		V_{CES}* (volts)	V_{CEO}▲ (volts)	Collector (amp.)	Transistor Dissip. # (watts)	Typical	Max.	Conditions	Typical	Min.	Conditions	Typical	Max.	Conditions
N1092	TO-5	60	30	0.5	1	3	10	Ic=200 ma.	20	10	Ic=200 ma.	75	1000	V_{CBO}=30 volts
N1067	TO-8■	60	30	0.5	2.5	3	10	Ic=200 ma.	35	15	Ic=200 ma.	75	1000	V_{CBO}=30 volts
N1068	TO-8■	60	30	1.5	5	1	2.67	Ic=750 ma.	38	15	Ic=750 ma.	75	1000	V_{CBO}=30 volts
N1069	TO-3	60	45	4	25	0.7	2	Ic=1.5 amp.	20	10	Ic=1.5 amp.	150	2000	V_{CBO}=30 volts
N1070	TO-3	60	45	4	25	0.4	0.67	Ic=1.5 amp.	20	10	Ic=1.5 amp.	150	2000	V_{CBO}=30 volts

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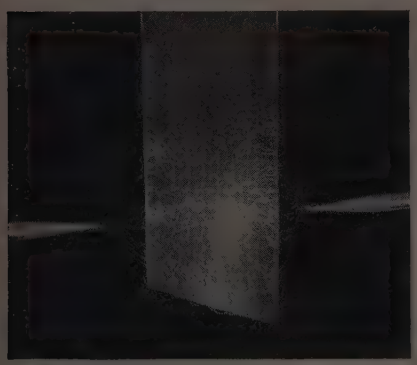

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Rate Gyro Design Variables

Angular Momentum—Product of rotor inertia and speed. Speed depends on frequency of rotor input and is, more or less, dictated by specs. For any given gimbal design, maximum size is fixed; therefore, rotor inertia depends entirely on rotor mass or choice of material. For the sake of economy, manufacturers make available a selection of from one to four rotors. If more than one rotor is available, the selection usually produces respective ratios of 2:1 in angular momentum. For any given motor design, the time-to-speed is directly proportional to angular momentum.

Maximum Gimbal Deflection—Normally specified by systems designer to limit cross-coupling effect. When a gimbal is deflected to maximum, it will also, because of the angular velocity about its input axis relative to the case, respond to angular velocities about the gyro spin axis as sin θ. For the same reason, this deflection further produces a slight non-linearity that is, in effect, as cos θ.

Spring Restraint Choice—Dictated by allowable natural frequency range and really more a compromise between hysteresis, angular momentum, and gimbal deflection. Because of inherent design, some manufacturers are limited in choice of spring rate. The type of restraint then becomes the decisive factor:

Torsion bars are limited by their lack of stability under transverse acceleration forces—particularly in units highly sensitive to low input rates (unless supported by bearings, forming a three-point suspension system). Tool tolerance on diameter and effective torsional responsive length are major machine set-up considerations that tend to minimize restraint selection by the supplier.

Cruciforms are mainly limited by the required machine tolerances. Predicted selection becomes too costly, for a trial-and-error type of machine setup has to be used for it.

Coil and leaf springs offer a wide selection of spring rates, but gimbal bearings require for support and so increase friction.

tolerance but rather describes the area of assurance in which the gain slope must lie. Certain environmental requirements must be specifically noted when the sensitivity band is defined in this way.

Angular acceleration response is commonly misunderstood. The gimbal of any rate gyro is of relatively high mass, which is spring-restrained. Therefore, when accelerated about its suspension axis —which is the output, or precession, axis of the gyro—the gimbal acts as an angular accelerometer. The angular acceleration response about the precession axis is directly proportional to the gimbal inertia and inversely proportional to the spring restraint.

With regard to *angular vibration* about the precession axis, the gyro again shows a natural acceleration response. When angular vibration is about the input axis, the rate gyro responds to the angular velocities. Angular acceleration about the rotor spin axis directly affects the angular momentum and is directly proportional to the instantaneous rotor velocity with respect to the mounting.

Static response due to continuous gravity forces raises only a question of testing. In the centrifuge test normally run on it, the gyro naturally responds to angular velocity about its sensitive axis. What is often not considered in these tests is the inherent angular velocities about the rotating arm and about the arm's axial vertex. These mechanically unbalanced forces acting on the centrifuge produce angular velocities that are readily detected, since the rate gyro is the most sensitive angular velocity instrument.

Frequency response characteristics are preferably specified as a curve or a band rather than as an undamped natural frequency and a damping ratio. This method assures the user of the overall response characteristics and gives slightly more leeway in design, which is reflected in the unit cost.

Three methods are commonly used in testing the frequency response of a second-order system:

• Step Function Input — This method checks only the damping function at its natural frequency.

more on page 168

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The CONOSEAL Joint utilizes a new concept of metal-to-metal sealing in which the conical metal gasket is completely encased by mating flanges. Compressed radially and axially, the gasket forms a superior seal that withstands extreme pressures and wide thermal cycling. Distortion, shock, even minor linear deflections are absorbed without loss of seal

The compact design of the Marman CONOSEAL Joint minimizes envelope clearance needed. Single bolt fastening simplifies installation. Ideal for fluid transfer lines and structural joints, it is available in four weight/strength configurations for both cut and ground installations. Mail coupon for complete new catalog.

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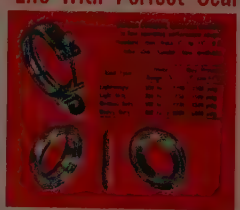

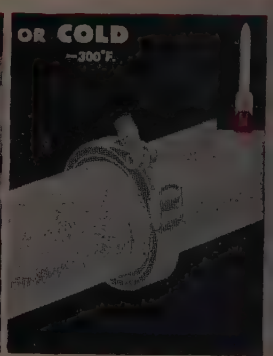

Only MARMAN CONOSEAL All-Metal Joint Gives You Perfect Seal

From red hot missile engine heat to the super cold of the laboratory —and at all temperatures in between—the versatile, all-metal Marman CONOSEAL Joint connects tubing and gives a perfect seal. Even linear deflections up to 1/16 inch, the result of temperature and pressure extremes on tubing of dissimilar metals, are accommodated without loss of perfect seal.

The Marman CONOSEAL Joint installs quickly because it fastens with a single bolt; requires minimum envelope clearance because of its compact design, assures indefinite shelf life because it is all metal. It is recommended for use with a wide range of fluids including liquid metals. Four configurations, from light to heavy duty, meet a wide range of requirements with maximum savings in weight.

Return the coupon for complete information.

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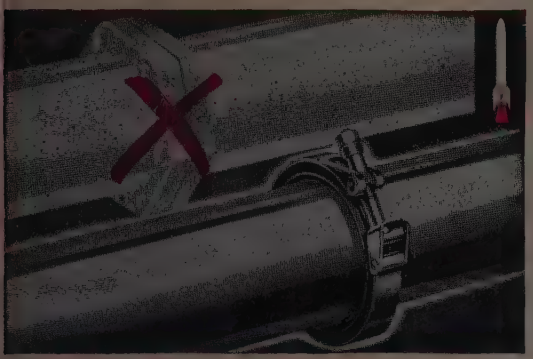

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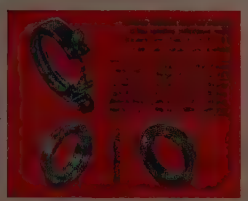
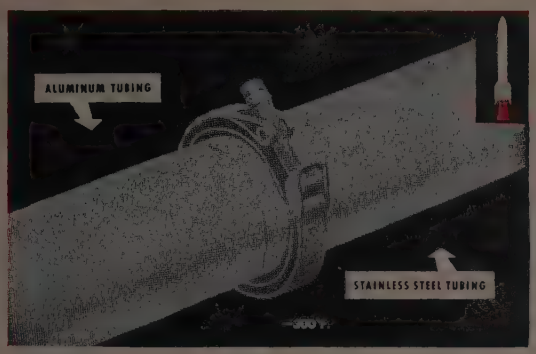
Connect high performance tubing quickly! Get perfect seal! Use the Marman CONOSEAL Joint that tightens with a single bolt—a simple, positive operation even in confined areas.

Important design advantages: The Marman CONOSEAL Joint requires minimum envelope clearance because its diameter is only slightly larger than the tubing it connects. Four configurations, light to heavy duty, provide maximum opportunities for weight savings.

Important operating advantages: The Marman CONOSEAL Joint seals perfectly at extreme temperatures. It joins tubing of dissimilar metals, and accommodates linear deflections up to 1/16 inch resulting from temperature and pressure variations. It has indefinite shelf life because it is all metal; and it may be used for many fluids, including liquid metals. Return the coupon for complete information.





MARMAN CONOSEAL Joints Assure Perfect Seal of Dissimilar Metals at Extreme Low Temperatures

Even at extreme cold of —300° F., tubing of dissimilar metals can be joined in a perfect seal by the all-metal CONOSEAL Joint. Seal is maintained through the full temperature range up to red hot 2000° F. (for applicable tubing). Strength and sealing capabilities are also unaffected by distortion, shock or minor linear deflections.

The Marman CONOSEAL Joint assures unlimited shelf life because it is made entirely of metals not subject to deterioration. Its compact design requires minimum envelope clearance; single bolt fastening simplifies installation. Recommended for a wide range of fluids, including liquid metals, the CONOSEAL Joint is available in four weight/strength configurations. Mail coupon below for complete new catalog.

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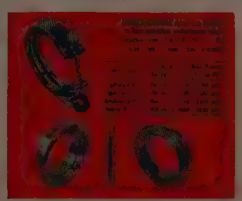

MARMAN Heavy-Duty CONOSEAL JOINT Seals Perfectly at High Temperatures and Pressures

Where extremes of pressure and temperature are standard operating conditions for fluid lines, specify the all-metal, Marman Heavy-Duty CONOSEAL Joint. It is designed to provide absolute dependability in connecting and sealing piping, even when subject to severe shock and distortion.

Marman Heavy-Duty CONOSEAL Joints provide maximum insurance against leakage or failure where dissimilar materials must be joined, such as stainless steel to aluminum or Zircaloy. Made entirely of metals not subject to deterioration, CONOSEAL Joints have long shelf life, require no maintenance.

Successfully performing now on jet and rocket engine test stands, high pressure fueling systems, missile test stands and launching platforms, the Heavy-Duty CONOSEAL Joint offers rugged dependability and simplicity of installation to meet a wide range of ground applications. Lightweight configurations of the CONOSEAL Joint are also available for aircraft and missile applications. Mail coupon below for full information.

Solve high performance tube and pipe joining problems with the versatile Marman all metal CONOSEAL Joint. Four configurations, covering temperature requirements from —300°F. to +2000°F. and pressure requirements from 1200 psig. to 6000 psig., are available for a wide range of missile, ground support equipment, aircraft and other applications. Weight-saving, space-saving Marman CONOSEAL Joints are leakproof, simplify tubing installation, accommodate linear deflections, assure indefinite shelf life. Return the coupon for complete information.

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0 to 7.5 volts for 0 to plus full scale acceleration, no neg. output
signal and power reference
+28v dc
0 v dc (power reference)
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Because of the mechanics of the test equipment, it has been found unreliable.

• Phase Lag—This method is fairly accurate through all damping values if the ratio of measured frequency to natural frequency is selected at a value at which measuring error is minimized. From the basic formula:

$$damping = [(1 - \beta^2)/2\beta] \tan\phi,$$

it can be seen that the incremental change of phase lag (ϕ) is greater at higher damping values when the frequency ratio (β) is lower. Thus for damping at 0.6, β is chosen at 0.5, but for damping at around 2, β is chosen at about 0.25.

If damping at 2 were to be measured at a frequency ratio (β) of 0.5, the accuracy needed for the measurement of phase lag angle would be beyond the scope of normally acceptable equipment.

• Amplitude—This method is the most accurate for measuring low damping values (below 0.7). It normally is not used when the steady-state rate must be measured below about five cps. In general, if damping is above 1 this method should not be used except in the case of very high frequency units.

Output ratio found from steady state

The steady state must be ascertained to find the output ratio (steady-state output divided by reading output at a preselected frequency ratio):

$$output\ ratio: \quad 1/\sqrt{(2\xi\beta)^2 + (1 - \beta^2)^2},$$

where ξ is the damping ratio.

For high damping values, the steady-state output must be measured at very low frequencies. This is often beyond the capabilities of conventional test equipment.

One mistake to be avoided is to use two different pieces of test equipment to find the output ratio — one to measure the steady-state output and another the reading output. Suitable equipment is not evenly enough matched in mechanical performance. Frequency response—whether stated as a band, a curve, or damping ratio and natural frequency—must stipulate how the response and at what points shall be measured.—End

STRATOPOWER

Shrinks the 4th dimension, too...

Cuts the time and cost lag between

development and production

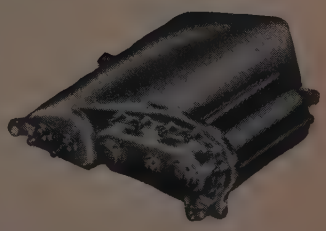
With each new design STRATOPOWER packs more and more performance into less and less space. This is evident in the equipment itself.

Less evident but no less true is the fact that each year STRATOPOWER is delivering more and more development results and production items in less and less *time*. This is because, at STRATOPOWER, contracted development is balanced with STRATOPOWER's own development effort to yield a continuous, well-rounded program of creative research in aircraft hydraulics.

No problem in hydraulics, however difficult, is ever completely dissimilar to projects already underway. The skill, tooling and materials are always at hand, whether the need is for testing at 1200°F (1200°F facilities were installed at STRATOPOWER early in 1958), production of a simple constant delivery pump (shipped by the thousands by STRATOPOWER), or development of a compact, complex hydraulic power package (such as the one shown in the accompanying illustration).

Talk to your STRATOPOWER representative. You may be surprised to hear him telling you what your hydraulic problems will be a year or two years from now. He knows, because STRATOPOWER is already there, anticipating the needs of the aircraft industry. It's no secret how STRATOPOWER licks the time lag to shrink the 4th dimension.

At STRATOPOWER, all lag-generating problems are solved yesterday.



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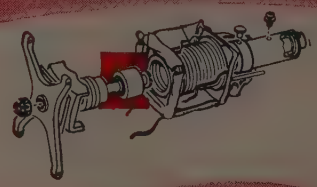
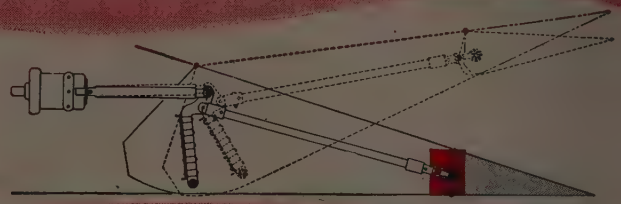
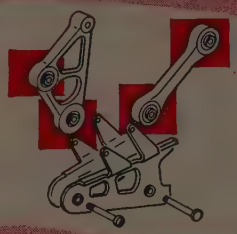


Elevator flight controls

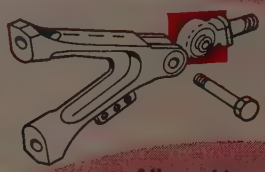


Aileron trim and servo tab control system

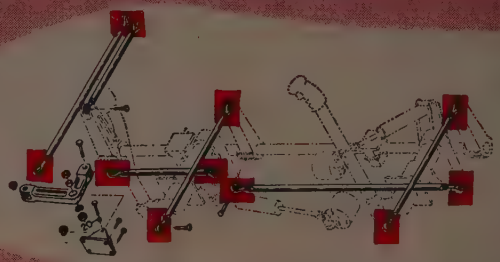
Main landing gear fulcrum and linkage



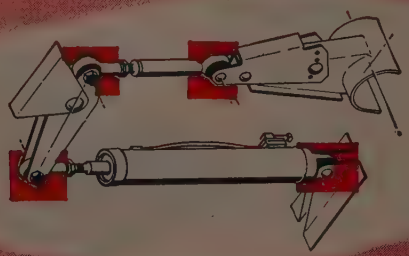
Wing flap hinge and linkage



Aileron hinge



Helicopter flight control group



Hydraulic actuator linkage

Helicopter blade pitch control link

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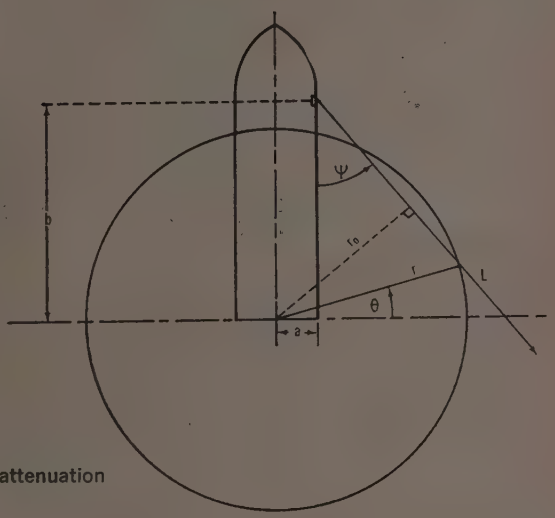
RF loss in rocket flame

easy to figure

One of the crucial problems in data or command transfer between a missile and the ground is the propagation loss from passage through the ionized exhaust flame. Knowing the effects of the flame on radio signals helps the designer in antenna placement and system selection. Here is a simple analysis for determining total attenuation.

by R. J. Schmelzer, Electromagnetics Dept., Missile Systems Div., Lockheed Aircraft Corp.*



GEOMETRY of flame attenuation calculation.

FLAME attenuation of electromagnetic waves is most severe in the RF region of the spectrum. This is unfortunate since, during most missile and rocket flights, it's almost impossible to avoid the need for some rearward transmission through the ionized exhaust trail.

Absorption and reactive effects are the basic sources of the attenuation. In turn these stem from the different ways in which the electric and magnetic fields of the signal influence the free electrons and molecules within the flame. Electrons of an ionized gas are affected most by a passing EM wave. The fields of the wave accelerate them to several hundred times the speeds of the heavier molecules.

The induced velocities of the electrons are also higher than their random thermal velocities (up to six km/sec compared with one km/sec.) Since the electrons move faster, their collision probability with molecules increases — however, not directly proportionally to the speed rise though, for the cross-section for collisions between electrons and molecules also changes with velocity. (For water it generally decreases.)

Part of the energy received by the electrons from the passing EM wave is transferred to the molecules, thus heating the gas. Were it not for these electron-molecule collisions, the energy, instead of being absorbed, would be returned to the EM wave.

Besides absorption, the EM wave will suffer a change of phase as well as reflection. One of the principal flame products is molecular water. It has the largest collision cross-section of all the flame particles, so most absorption is due to electron-water molecule collisions. The water molecule is also lighter than most other flame products and therefore will diffuse out more rapidly from the exhaust axis.

Flame from a fixed rocket at sea level has a diameter not much larger than that of the exhaust nozzle—the ejected material has a high rearward velocity and the pressure within the flame is near atmospheric. In flight, the flame is generally even more constrained by the air stream flowing past the rocket vehicle's outer surface. However, there is some dispersal due to eddies and irregularities in the aerodynamic flow.

Free electrons leaving the flame in the transverse direction are

more on next page

*Missile Systems Div., Lockheed Aircraft Corp., Sunnyvale, Calif.

quickly lost by attachment to the surrounding dense cool air. Most electrons, however, are moving parallel (or nearly so) to the main stream of the flame. These have a longer free life, but are lost in turn by recombination and attachment, both within the flame and in the air with which it becomes mixed downstream.

As the rocket leaves sea level, the atmospheric pressure decreases, and the flame begins to expand. In addition, the sweeping action of the air stream decreases (for the same velocity) and the mean free path of the electrons increases.

This increase not only decreases the amount of energy collisions with water molecules but also the rate of recombination and attachment. While the first process tends to decrease the absorption of a passing EM wave, the latter tends to increase it. At the same time, the expanding envelope of the flame increases the geometrical path length, tending to increase the EM wave absorption. However, the effect of the increasing mean free path outweighs the other three effects, and attenuation decreases with altitude.

Two independent groups of flame particles

The flame particles may be considered as belonging to two superimposed but effectively independent groups:

- A directed group traveling along the exhaust axis is produced through the conversion of internal combustion pressure into the high velocities of ejection by the exhaust nozzle.
- A more or less random group is caused by turbulence and internal thermal collision.

Most of the particles fall into the first group, but the second is more important for signal propagation between a rocket vehicle and its base. While diffusion and scattering from the main stream contribute to the ionized material outside the cylinder defined by the rearward projection of the rocket body, the random group furnishes most of the absorbing electrons. These are "out of step" and therefore leave the stream directly or by means of a higher collision frequency.

Some of the random electrons leave the stream with a higher forward velocity component than the rocket itself and therefore pass by

more on page 174

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STEPS IN THE RACE TO OUTER SPACE

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In the background, two of the expedition's ferry ships are seen; one landing, one unloading in the bright Earthlight.

Inertial navigation systems will play an increasing role in the exploration of outer space. ***ARMA***, now providing such systems for the Air Force ATLAS and TITAN ICBM's, will be in the vanguard of the race to outer space. ***ARMA*** . . . Garden City, New York. A Division of American Bosch Arma Corporation.

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the rocket. They would be important sources of attenuation for antennas on the rocket vehicle body—if there were enough of them. However, since thermal velocities are only about one km/sec (at 1500 deg C), while the exhaust (directed) velocity is 2-3 km/sec, few particles belonging to a random group at the exit plane of the nozzle would be fast enough to pass the rocket. Most of them would have to be scattered out of the stream and in the forward direction by collision after leaving the nozzle.

Less material density for forward locations

Also, most electrons would have to be near the surface of the dense flame to escape. Therefore material forward of the exit plane should be far less dense than the material in the exhaust, and the decrease in density should be the greater farther forward the location.

Treating all of these factors rigorously would hopelessly complicate the problem of determining attenuation. Fortunately, a simple analysis is possible.

Assume that the center of the flame is expanding uniformly into a vacuum from a sphere centered at the middle of the nozzle exit and having a radius equal to that of the nozzle. This gives too high a density forward and too little rearward. However, since the propagation path goes through a chord, there is partial compensation of electrical path length. This is frequently true in circular and spherical problems. Also, the highest density region is shadowed by the rocket body for most suitable antennas.

Neglecting the effects of intermolecular collisions and chemical reactions in the expanding exhaust, the density of the flame products in this spherical model would fall off as the inverse square of the radial distance (r) from the center of the exit plane (see *Diagram*). The effect of collisions will be to retard the mass flow outward, with the result that the density will fall off more rapidly. An approximate analysis indicates an inverse cube relationship.

Assuming also that the attenuation coefficient (α) is proportional to the density of flame products (for relatively low densities of about 10^6 per cubic centimeter away from the main stream, this

more on page 176

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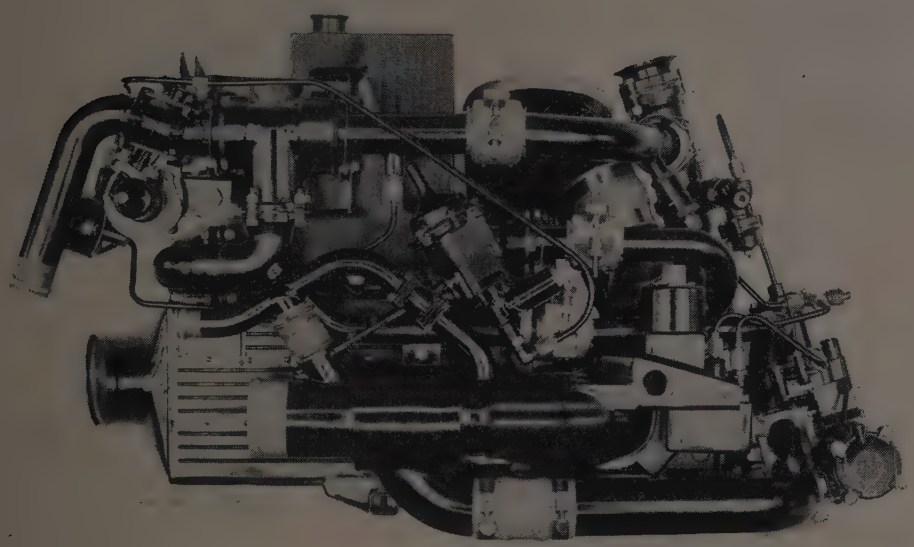

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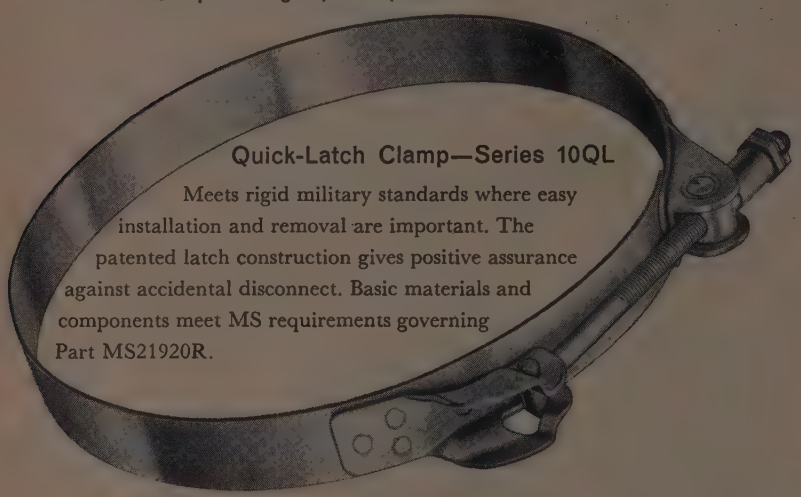
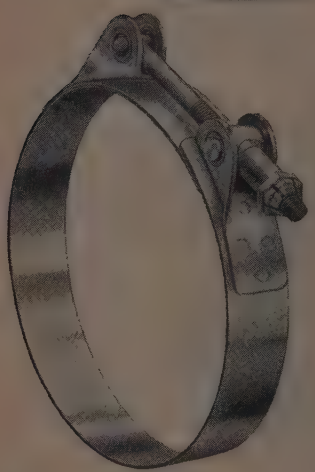


Quick-Latch Clamp—Series 10QL

Meets rigid military standards where easy installation and removal are important. The patented latch construction gives positive assurance against accidental disconnect. Basic materials and components meet MS requirements governing Part MS21920R.



T-Bolt Clamp—Series 10T

Same as 10QL but without patented quick-latch, and recommended for more permanent applications. Meets MS requirements governing Part MS21920.

STAINLESS STEEL AIRCRAFT CLAMPS

Complete range of sizes

Type AN737-TW (with shoe)

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CLAMPS for Every Application

8825

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is reasonably accurate) then:

(1) $a = a_0\ a_0^3/r^3$,

where a_0 is the attenuation coeff cient in the unexpanded flame (d termined from measured values and a is its radius. The polar equ tion of the propagation path i

(2) $r = r_0/\cos(\psi - \theta)$,

where r_0 is the minimum distanc between the ray path and the or gin is given by $r_0 = a\cos\psi + b\sin\psi$, where ψ is the angle betwee the rocket axis and the ray pat and b is the distance from the ex plane to the antenna.

The increment of length alo the ray path (L) is

(3) $ds = \sqrt{1 + r^2(d\theta/dr)^2}\,d$

Differentiating *Equation 2* with r spect to r and solving for $d\theta/d$ we get:

(4) $d\theta/dr = \cot(\theta - \psi)/$

Substituting *Equation 4* in *Equ tion 3* gives:

(5) $ds = r\,dr/\sqrt{r^2 - r_0^2}$.

Integration of the attenuatio coefficient (α) over all elemen from the antenna to infinity pr vides the total attenuation (A along the propagation path (L).

$$(6)\quad A = \int_{r_0}^{r_1} \alpha\,ds + \int_{r_0}^{\infty} \alpha\,ds,$$

where $r_1 = \sqrt{a^2 + b^2}$ is the radia distance from the origin to the a tenna. Since r_0 is the minimum di tance from the ray path to the or gin, $r_0 \leqq r_1$. Substituting *Equatio 1 & 5* in *Equation 6* yields, upo integration:

(7) $A = (\alpha_0 a^3/r_0^2)$
$[1 + (b\cos\psi - a\sin\psi)/r_1]$.

At X-band, 0.04 db/cm is typical for α_0

A typical measured value of α is 0.04 db/cm at X-band. Usi this value along with typical valu of 40 cm (15.8 in.) for a and 40 cm (13 ft) for b gives 3.3 db f the most severe case of transmi sion parallel to the rocket ax ($\psi = 0$). This is quite close values obtained by much mo elaborate methods.

Finding attenuation and pha shift is further complicated by r fraction through and diffracti around the variable density flam These should be treated as tw superimposed parts, one steady an the other randomly fluctuating. I terference due to propagation b multiple paths is another distin possibility. However, all these e forts appear to be secondary simple communications.

more on page 17

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FLIGHT
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SAFE
LAUNCHING
WITH CANNON HIGH-RELIABILITY PLUGS
Performance of missile launching connectors cannot be "hit or miss." Both safe launching and safe flight are required. And that's where Cannon's reputation for quality and design experience can help . . . with the most complete and most reliable line available.
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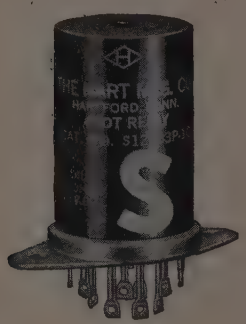
Please Refer to Dept. 115

4 Ounce Contact Force Gives Relay Reliability

Contact force of 4 ounces per contact on 50 "G" models and 2 ounces per contact on 30 "G" models of "Diamond H" Series R and Series S miniature, hermetically sealed, aircraft type relays is one of the most important factors in their proven high reliability.

Though absolute reliability of any similar device is impossible to guarantee—a bitter fact of life recognized by all electronic engineers—close approach to this goal by the relays manufactured by The Hart Manufacturing Company is the basic reason they are found today on many of this country's headline-making missiles.



In addition to contact force far beyond that found on other relays, "Diamond H" relays have greater contact cleanliness. Self-contamination is virtually eliminated by a completely inorganic switch mechanism, as well as use of coil materials which will not dust, flake or out-gas.

Finally, the high degree of reliability that is designed into these relays is maintained in their manufacture by high quality workmanship and a stringent inspection policy at every stage.

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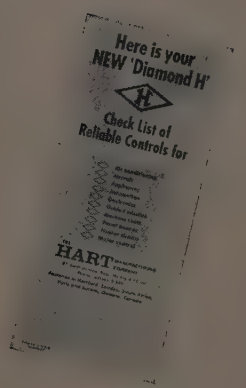
4PDT units, they offer an extremely broad range of performance characteristics, including temperature ranges from —65° C. to 125° and 200° C.; ratings to 10 A., 120 V., A. C., and 26½ V., D. C., with special ratings to 400 ma. at 350 V., D. C., or down to millivolts and milliamperes. Dry and wet circuits may be safely intermixed.



For more information, write today for Bulletins R250 and S260. For quick facts about "Diamond H" switches, thermostats and other devices, ask also for a copy of the "Diamond H" Check List of Reliable Controls.

THE HART MANUFACTURING COMPANY

212 Bartholomew Ave., Hartford 1, Conn.
Phone JAckson 5-3491

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In some of the earlier rocket vehicles (such as the V-2), antennas were located in the rear edges of the fins next to the engine. As a result, the antennas were enveloped in the exhaust flame, and there was a problem of antenna mismatch as well as attenuation through the most highly ionized region.

An antenna is usually matched to free space with a refractive index of 1. However, with a flame present, the signal has to pass into a medium whose index is:

$$(8) \quad n = \sqrt{1 - Ne^2/m\,\epsilon_0\,\omega^2},$$

where N is the number of electrons per unit volume; m, the mass of the electron; ϵ_0, the dielectric constant of vacuum; and ω, the angular frequency. For a typical value of N near the exhaust (10^{10} electrons per cubic centimeter), the refractive index is a small fraction, so that the magnitude of the reflection coefficient—$r = (n-1)/(n+1)$—is nearly 1 and the antenna is badly mismatched for frequencies of a few hundred megacycles or less.

By moving the antennas forward out of the direct flame, the mismatch part of the loss is nearly eliminated. Moving them as far forward as possible—preferably into the nose—minimizes the attenuation due to propagation through the diffused flame.—End

Discoverer Tracked

Tumbling of Discoverer I, caused by attitude stabilization failure was the reason for the sporadic communications between satellite and ground tracking stations.

After four days of uncertainty, some 40 electronic sightings (signals received from Discoverer I and radio signals bounced off its trail) from stations in continental U.S., Alaska, and Hawaii finally confirmed that the 19-ft, 1300-lb satellite was in its expected polar orbit.

According to the Ithaca, N.Y., tracking station of GE's Light Military Electronics Dept., Discoverer I is orbiting in two sections. GE detects and tracks satellites with signals (on a WWV frequency) that are bounced off the satellite's ionized trail. The Discoverer I sightings indicate that the two sections are about 30 minutes apart in orbits of 95.6 and 95.1 minutes per revolutions, respectively.

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"When we consider a complex system that involves a high speed computer, we look on the computer program as a system component—one requiring the same attention as the hardware, and designed to mesh with other components. We feel that the program must not simply be patched in later. This point of view means that SDC programmers are participants in the development of a system and that they influence the design of components such as computers and communication links, in much the same way as hardware design influences computer programs.

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T. B. Steel

Senior Computer Systems Specialist

SDC

SYSTEM DEVELOPMENT CORPORATION

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space/aeronautics

CONFIDENTIAL

April 1959
(good until 6/15/59)

Employment Inquiry Form

(NOT an application for employment)

THIS INQUIRY FORM is a service that makes it easier for the interested reader to explore employment opportunities with organizations featuring recruitments advertising **in this issue.**

To use this Form, follow these simple steps:

(1) Tear out this page.

(2) Check off the organization(s) listed below whose employment offers are of interest to you. **Use typewriter or pencil.**

(3) Turn to the back page of this Form and answer the questions on it.

(4) Mail this form (in a stamped envelope) to:

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SPACE/AERONAUTICS
205 East 42nd St.
New York 17, N.Y.

We will do the rest and promptly forward a copy of your Inquiry Form to each of the organizations you have checked. Depending on their specific personnel requirements, they will get in touch with you at your home.

I am interested in the employment opportunities at:

☐ Aerojet General Corp.	186	☐ National Aeronautics & Space Admin.	290
☐ AiResearch Mfg. Co.	76	North American Aviation	
☐ AVCO Mfg. Corp.	9	☐ Autonetics Div.	183
☐ Bendix Aviation Corp.; York Div.	186	☐ Rocketdyne Div.	100
☐ Garrett Corp.	76	☐ R C A	172
☐ General Electric Co.; Flight Propulsion Div.	184	☐ Rohr Aircraft Corp.	184
☐ Marquardt Aircraft Co.	238, 239	☐ Systems Development Corp.	180
☐ Martin Co., The	153		

OTHER (Some organizations' recruitment advertising in this issue may have arrived too late for inclusion in the above list. If you are interested in the employment offers of any of these organizations, just note its name and the page number of its advertisement in this space. Please refer only to ads keyed to this form.): _____

_____

_____

NOTE: If you have an immediate interest in any special employment opportunity advertised in this issue and would like to give more details about your qualifications than can be noted on this Form, we advise you to send your resume directly to the person or department given in the advertisement. We'd appreciate it if you'd mention SPACE/AERONAUTICS in your application.

←Check Employment Inquiry Form on Page 181

space/aeronautics

CONFIDENTIAL

April 1959
(good until 6/15/59)

Employment Inquiry Form

Please type or print (with pencil) (NOT an application for employment)

FIELDS OF INTEREST (in order of importance, note the general fields in which you would like to work—e.g., basic research, dynamics, structures, rocket propulsion, electronic systems, pneumatics, testing, materials, production, ground support, etc.) : _____

SPECIALIZED JOB EXPERIENCE (describe the specific technical areas in which you have worked —e.g., flutter, fatigue, fuel systems, circuit miniaturization, servo systems, hydraulic pumps, tool engineering, orbit mechanics, telemetry, data processing, wind tunnel testing, etc.) : _____

JOBS AND EDUCATION

List your last 3 employers:

EMPLOYER	CITY & STATE	YEARS EMPLOYED	JOB TITLE OR FUNCTION

List your college and university degrees:

SCHOOL	YEARS ATTENDED	DEGREE

Special Training _____

PERSONAL DATA

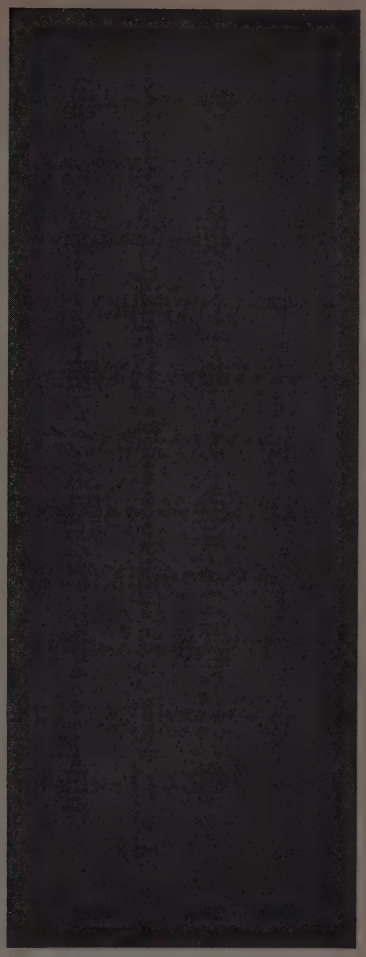
AGE ..... U. S. CITIZEN ☐ YES ☐ NO If not, when do you expect to become a citizen? .....

Name: .....

Home Address: .....

Home Telephone: .....

Make sure you have checked the companies you are interested in on the other side of this Form. Then put the Form in a stamped envelope and mail it to Space/Aeronautics.



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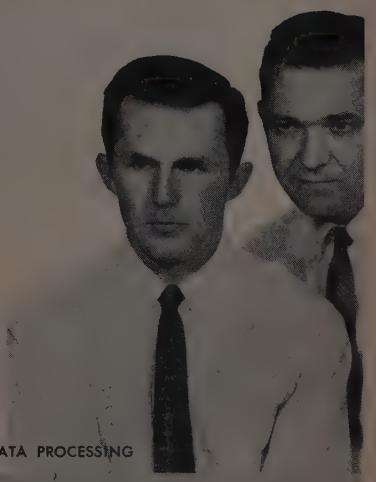

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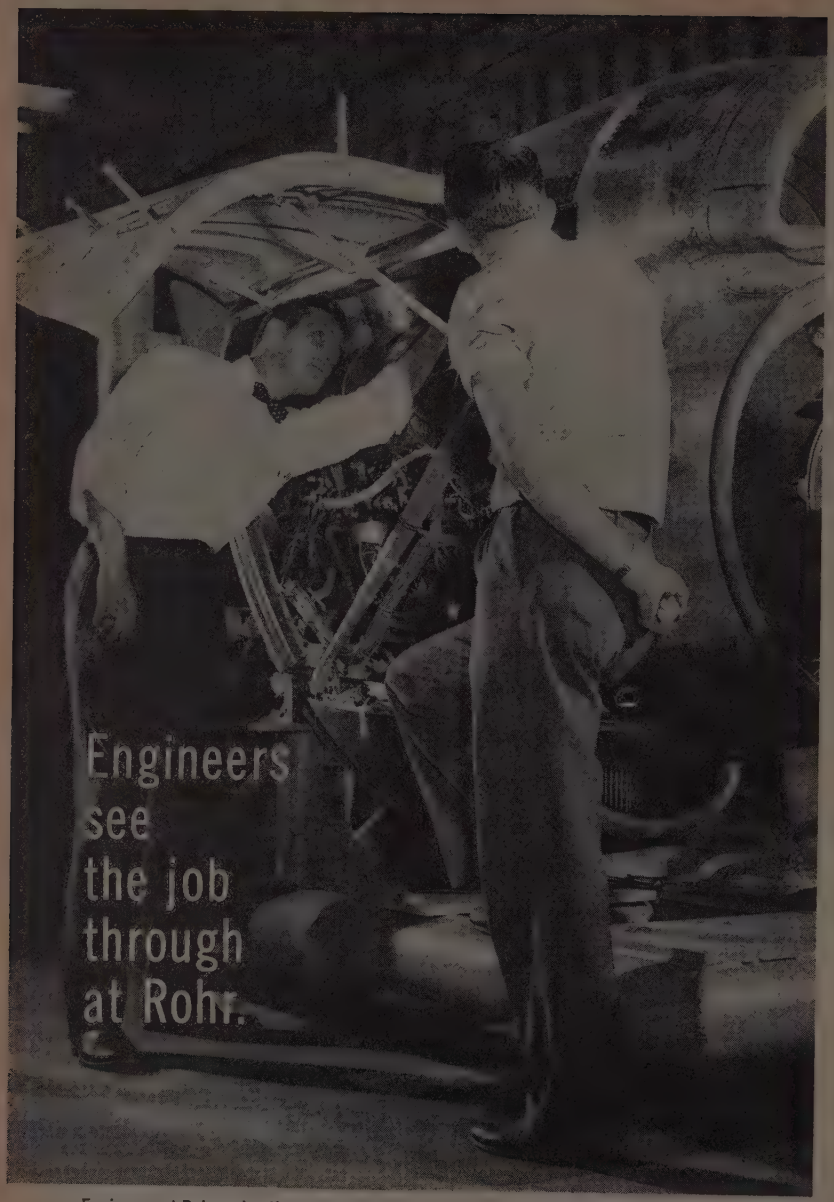

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GENERAL ELECTRIC
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B.S. with 2 to 4 years' experience in installation of electronic and electromechanical equipment in aircraft. Aircraft company experience is desirable.

B.S. with 2 to 4 years' experience in flight testing of complex electronic equipment, preferably in high performance air vehicles.

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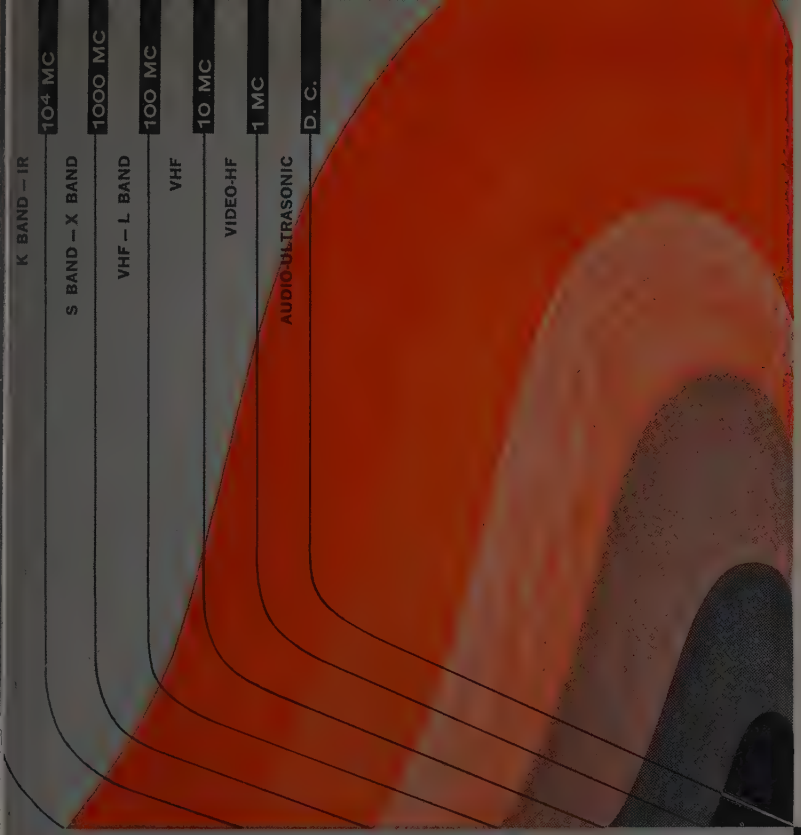

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product index to advertising

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Similar indexes to services and employment opportunities featured in ads follow this index.

Advertisements for which complete proofs were not available to the Editorial Department by the closing date are not necessarily covered by these indexes. (Proofs can be forwarded internally by the Production Department only for advertisements meeting the closing dates.)

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MOMENT IN HISTORY

THIS IS THE "FIRST FLIGHT" of the new Air Force TITAN, America's most powerful weapon and our No. 1 challenger in the big-missile field. Time: 2/6/59—4:22 p.m. EST.

The most important thing about this moment in history is not visible here—and it is this:

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Martin-Denver
is one of the
seven divisions
of The Martin Company

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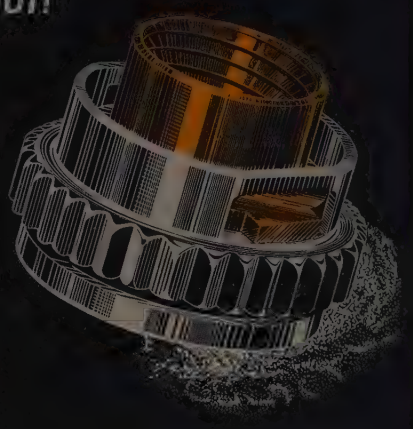

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For complete information, write to Department 29

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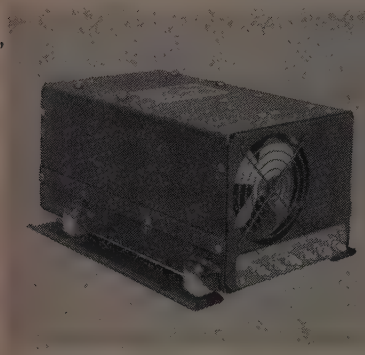

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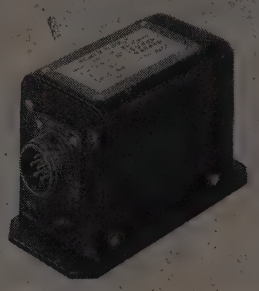
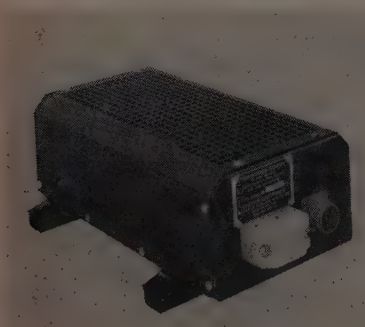
shock mounted model 28V100-5

SILICON TR UNIT
convection cooled model 28VS100C



DC-DC CONVERTER
dual output model 75D2D50

STATIC DC-AC INVERTER
high temperature effiency, model 283150



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CHATHAM ELECTRONICS
division of
TUNG-SOL ELECTRIC INC.

CHATHAM—WORLD'S LEADING SUPPLIER OF AIRBORNE CONVERSION EQUIPMENT

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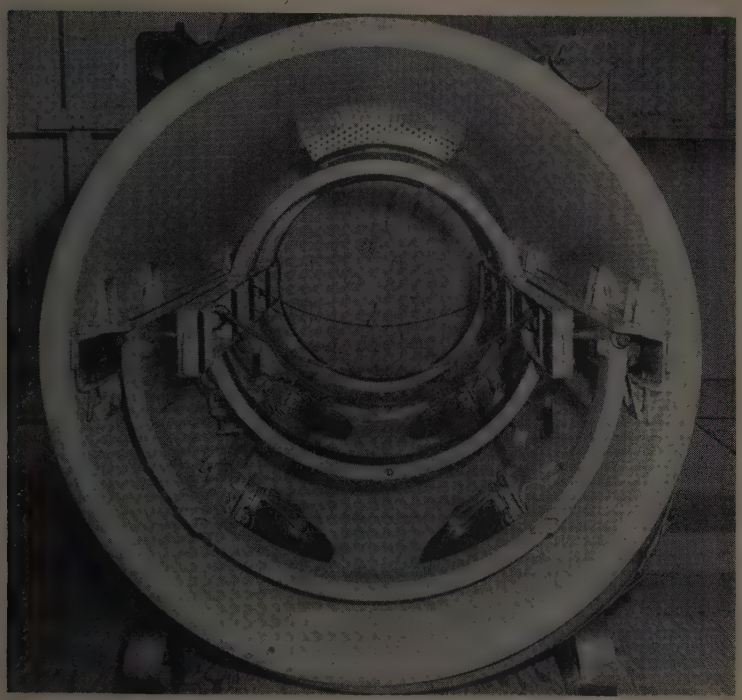
equipment briefs



PRESSURIZED STORAGE AND SHIPPING

THE integrated design of the combination ground handling, shipping container, and storage unit developed by Harco Containers Div. Harbor Boat Building Co., 258 Cannery St., Terminal Island, Calif., makes extensive use of fiberglass laminates to keep down weight. The basic design can be tailored to take external aircraft stores, missiles, rocket engines, jet engines, accessories, electro-mechanical assemblies, etc.

The basic configuration consists of a center section, in which is nested a shock mounted trailer or dolly, and two end sections that are attached by V-band quick release clamps. For moisture protection during shipping or storage, the assembly can be pressurized to 5-10 psi with air or inert gas.

After decompression of the Harco container, less than 60 seconds are required to remove both end sections, says the company, and withdraw the loaded trailer from the container. On removal from the container, the stores are ready for immediate movement without the need for any other ground handling equipment.

For empty shipment of the container with the cradle installed, the end sections can be reversed so that they fit into the center section rather than extend out at the ends. This cuts the cubic shipping space of return deliveries by about 50 per cent, says Harco. Write in No. 63 on Reader Service Card for more information.

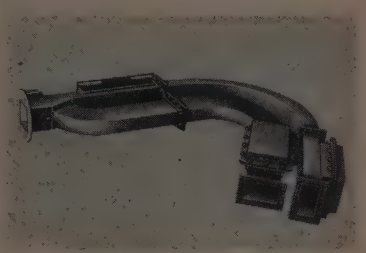
LIQUID ARGON SUPPLY

BY BUYING its argon supply in liquid form, Ford Motor has saved over $180,000 in 17 months of welding operations at its Chicago Aircraft Engine Division. Ford, which is building the J57 under license from P&WA, uses a Linde argon-shielded Heliarc process for most of the high-alloy titanium welding on the turbojet.

Helped by Linde Co., 30 E. 42nd St., New York 17, N. Y., Ford studied its argon requirements, examining sources and the problems of shipment in liquid and in gaseous form (in terms of purchasing, handling, storage, and distribution cost). It then decided it would pay to give Linde a blanket order to provide storage facilities and furnish the argon in liquid form.

A liquid-to-gas converter was installed along with a spherical storage tank whose capacity was the equivalent of 100,000 cu ft of gaseous argon. Linde services the installation with Driox (liquid argon) from its nationwide network of production, storage, and transportation facilities.

Direct and indirect savings over 17 months amounted to over $180-000, says Ford. Figures show that monthly average consumption is rising so that even greater savings are expected in the future. Write in No. 56 on Reader-Service Card for more information.



NOVEL DUAL-POLARIZED HORN

A DUAL-POLARIZED feed horn for large-sized waveguide recently placed in production by D. S. Kennedy & Co., Cohasset, Mass., features a unique double-waveguide input arrangement. (The usual dual-polarized horn uses a coax input.)

Kennedy points out that the new feature has the advantage of providing a common center of radiation for both polarization signals. Maximum power transmission is obtained in both cases. The horn can handle 10 kw with more than 30 db decoupling between the signals.

The unit pictured is meant to operate in the frequency ranges of 1700-2400, 755-985, and 400-450

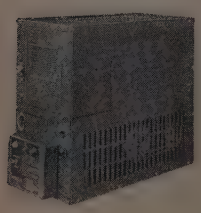
more on next page

HEAT in military applications

HUNTER SPACE and PERSONNEL HEATERS

for mobile and portable shelters

Hunter Heaters are designed and manufactured in conformity with military specifications for space, equipment and personnel heating in ground support systems for missiles, radar, microwave, monitoring centers, etc. Five basic Hunter models are available currently, some multi-fuel-burning, others which burn any type gasoline, each custom-engineered to specific requirements for the area of end use. Model range is from 15,000 to 60,000 BTU/Hour output, all air-circulating, all thermostatically controlled, all designed for cold starts as low as –65°F. One of the current models is . . .



MODEL UH-68

Produced in conformity with military specification MIL-H 11511B • 60,000 BTU/Hr. output • multi-fuel burning • designated "spec" equipment in Corps of Engineers' Expansible Body Program, AN/GPQ-T1 Air Force Trainer Radar and many other end item projects in the GCA category • also custom-engineered for the Matador Missile System communications shelters.

MODEL DH-73: 50,000 BTU/Hr. • for guided missile ground control equipment.

MODEL UH-73-2: 50,000 BTU/Hr. • used in U.S. Signal Corps AN/MSG-4.

MODEL UH-58-SC-1A: 60,000 BTU/Hr. • used in S-44, CPN/18A, MPS/7, M-109, etc.

MODEL UH-47-4S: 15,000 BTU/Hr. • for use in small and medium size shelters.

Engine heaters, instant lighting torches, refrigeration and air conditioning units are other Hunter products for military applications.

get these brochures TODAY! for complete details

MH-162 "Space Heaters" MH-166 "Engine Heaters" MH-167 "Military Torches"

HUNTER MANUFACTURING CO. HEATING AND REFRIGERATION SYSTEMS

30529 AURORA RD. SOLON, OHIO

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mc. The new horn is also available in other frequencies, says Kennedy. Write in No. 66 on Reader-Service Card for more information.

AIRBORNE ANALOG-DIGITAL CONVERTER

RUGGED as part of its design to missile specs, the new airborne analog-digital converter developed by CG Electronics, Albuquerque, N. M., is said to be the world's smallest. Using solid-state components throughout in etched-circuit subsystems, the 7x3x14-in. device scans 12 input channels and can handle up to 50 or more if the nominal scan rate of 120 cps is upped accordingly. The scan rate ranges from 100 to 300 cps, with response rates that can go as high as one megacycle.

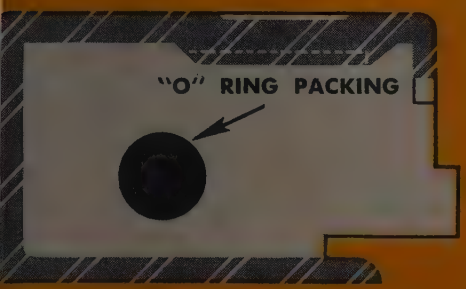
The converter uses pulse code modulation. Outputs can be furnished for magnetic and punched tapes, punched cards, and nixie tube readout or telemetry link. The device contains an automatic error checking system and digital readout, with surge protection for ±20 V dc or peak pulse, the nominal input range being ±5 V dc. Input impedance is one megohm for all frequencies from dc to 40 cps. Output impedance is 600 ohms maximum from dc to kc. Maximum required operating power is 25 W, obtained from a built-in, transistorized 28-V dc supply. Absolute accuracy is given as no more than a 20-mv error over the range of ±2.5 V or a 40-mv from ±2.5 to five volts.

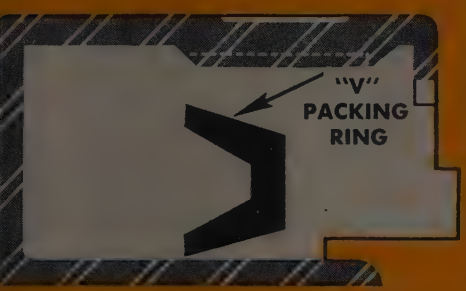
The converter operates from 20 to 165 deg F. It can take an 18-G shock and constant acceleration up

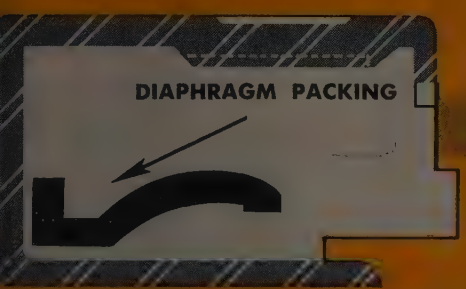
more on page 199

Write in No. 385 on Reader Service Card

GITS HH-TYPE SEAL SERIES







VITON "A"

All packings illustrated are available with new Viton "A" rubber compound, for highest temperature resistance and maximum resistance to aircraft and hydraulic fuels and lubricants.

GITS

Extra Flexibility For Your Seal Applications!

ONE SEAL ENVELOPE WITH CHOICE OF FIVE SEAL PACKINGS

Use of this one standard Gits HH-type seal envelope — with your choice of the five seal packing arrangements illustrated at left — permits effective sealing (in the same seal cavity) over the widest possible range of operating conditions. And all these Gits Shaft Seals meet standard minimum space requirements of the aircraft and missile industry.

Standard metal parts are stainless steel, except when the Gits Engineering Department recommends other materials to suit specific applications.

The sealing and packing members are engineered of proper materials to suit the operating conditions of each individual application.

Gits maintains the most complete facilities for design, engineering, research, development and testing, as well as the most modern manufacturing equipment. The Gits Engineering Department, with almost half a century of experience, has the know-how to blend proper materials with outstanding design, to make seals work better for you. Send for full information.

GITS BROS. MFG. CO.

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NEW! *Gits engineering advancement practically eliminates hysteresis or drag. Write for full details.*

Bendix* has long been a leader in supplying controls and fuel systems for all types of aircraft engines. Today, Bendix is proving to be a natural for new challenges in related missile fields—on ram jets, rockets, nuclear power, and other advanced propulsion systems. So, when it comes to controls, remember that Bendix has the background—and is anxious to share it in solving your problems. *REG. U.S. PAT. OFF.

BENDIX PRODUCTS DIVISION **SOUTH BEND, IND.**

Bendix AVIATION CORPORATION

to 25 G in all planes. Applications include conversion of guidance and stability data for such vehicles as satellites, missiles, and drones as well as high reliability measurements in ground stations for data acquisition and reduction systems. Write in No. 64 on Reader Service Card for more information.

THERMOGRAPH INSPECTION

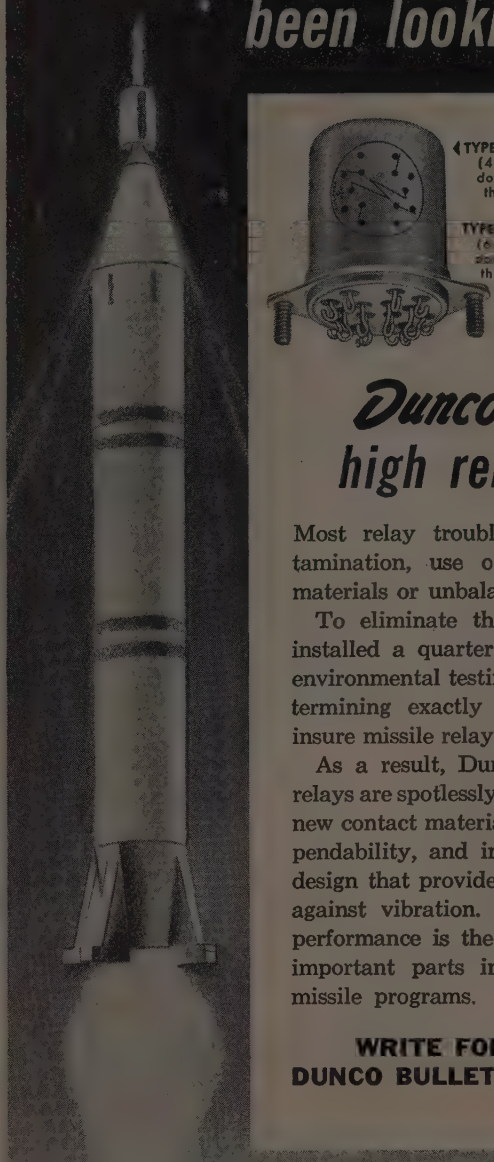
EXPERIMENTAL work by the Materials Engineering Div., The Martin Co., Baltimore 3, Md., indicates that temperature patterns of the sort illustrated here may open up an easy, accurate way to detect flaws hidden beneath the skin of composite panels. The underlying core structure of a brazed stainless steel honeycomb panel is clearly visible in this unretouched thermograph.

The flow visualization technique to produce the thermograph was developed by Dr. Samuel Katzoff at Langley AFB, Va., to show the effect of air flowing over aerodynamic wind tunnel models. The top surface of the specimen is coated with an oil film, and infrared heat is applied underneath. The heat traveling upward along the most conductive path displaces the surface film in a pattern that reflects the arrangement of the conductive material.

Applied to composite panels, the heat is conducted by the honeycomb core so that the temperature pattern appearing on the top skin is a picture of the core-to-skin joint. Thermographs clearly show irregularities in cell patterns, excess agglomeration of brazing material at junctions, and intimacy of the core-to-skin contact. They

more on next page

MISSILE RELAYS
with the reliability you've been looking for!



Dunco means high reliability!

Most relay troubles come from contamination, use of improper contact materials or unbalanced design.

To eliminate these, Struthers-Dunn installed a quarter of a million dollar environmental testing laboratory for determining exactly what is needed to insure missile relay reliability.

As a result, Dunco FC-6 and FC-4 relays are spotlessly clean, have a unique new contact material of outstanding dependability, and incorporate improved design that provides positive protection against vibration. Best proof of their performance is the fact that they play important parts in at least six vital missile programs.

WRITE FOR DUNCO BULLETIN FC

S-D

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Makers of the World's Largest Assortment of Relays

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8298-SR

An important advantage in missile development

The critical environmental specifications of current air weapons systems are being met by dependable Silicone rubber parts. Only Silicone rubbers retain their rubber-like characteristics under severe operating conditions . . . provide temperature resistance ranging from −160° to +600° F. Stalwart's modern Silicone Department is now producing accurate rubber parts for jet engines, instruments and other electronic equipment. Extruded and calendered *Silicone sponge* parts are produced for aircraft gasket and seal applications. Write us today about your special rubber parts problem.

Write today for your Stalwart Catalog SR-59

STALWART RUBBER COMPANY

363 Northfield Road • Bedford, Ohio. Plants in Jasper, Georgia and Bedford, Ohio.

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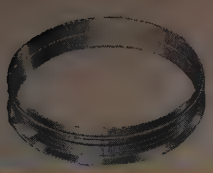
provide an instantaneous extended coverage picture that can be interpreted immediately by visual inspection or recorded photographically. Martin is studying the technique for possible use in continuous inspection and quality control work.

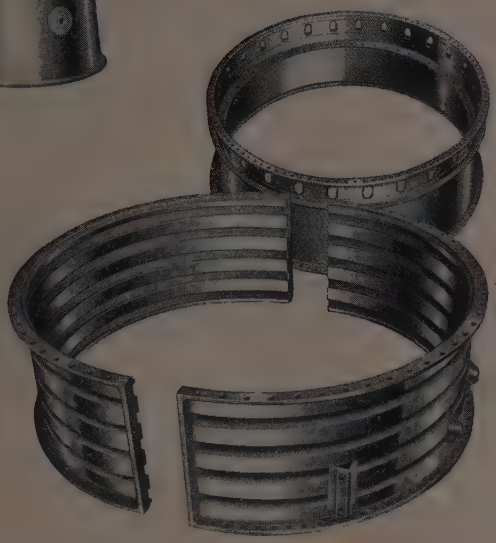
PERISCOPE FOR RUNWAY CONTROL

BECAUSE the ground roll needs of SAC's new, long-range Boeing B-52G bombers had pushed the end of the main runway at Westover AFB, Chicopee, Mass., out of sight of the control tower, means had to be found to extend the tower operators' line of sight—despite intervening hangars and other structures. Raytheon Mfg. Co., Waltham 54, Mass., met the problem with a closed-circuit TV installation using a microwave link to relay the picture to the tower.

A Dage closed-circuit TV camera was mounted within a special "greenhouse" atop the furthest structure. The microwave link beams a picture of the former blind spot back to a monitor in the control tower, nearly a mile away. The use of microwave eliminates overhead wires or entrenched cabling. The unmanned camera is equipped with a zoom lens to give the control officer either a panoramic view or a closeup of a jet's identification number. The system is cheap enough and flexible enough for use at various military and commercial fields, says Raytheon. Write in No. 65 on Reader Service Card for more information.



Looking for a Fabricating Source...



of welded precision assemblies?

As a major producer of circular parts and welded components for the aircraft industry, Amweld® possesses special knowledge and techniques for forming, welding, and machining of assemblies. Fabricating of aluminum, titanium, stainless, and heat-resistant alloys is a major part of this work. Experienced metallurgical and engineering staffs, plus a skilled work force, make up this team of fabricating specialists which is available to you on a subcontracting or experimental work basis.

If you would like to obtain complete information on the capabilities of American Welding and how we can be of assistance to you—phone or write today. Our local representative will be happy to call and discuss your requirements.

AMERICAN WELDING

Write for complete information.

NEW 20-page catalog of Amweld Rings, Bands, and Welded Assemblies.

NEW booklet entitled, "HOW AMWELD FLASH BUTT-WELDED RINGS ARE PRODUCED."

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558 Dietz Road • Warren, Ohio

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The Case For 105mm Miniaturization of Engineering Drawings

Micro-Master® 105mm, supplied by K&E, is the only system designed specifically for engineering drawings

Micro-Master 105mm offers the general advantages you expect of any miniaturization system — space savings, protection of costly originals, and ready distribution of duplicates. But Micro-Master provides these advantages *without* over-mechanization. A 105mm negative — measuring a generous 4 by 6 inches — is large enough to be located easily and read quickly without elaborate scanning and sorting devices. In addition, a national network of K&E dealers stands ready to provide the 105mm service you need.

A Complete System from Film to Print

Micro-Master is a totally integrated system for photographing, film processing and final reproduction or projection printing. Completely precision-engineered — from optics through films, papers and chemicals — the system provides extremely sharp, high-contrast "thin" negatives that furnish high-quality, absolutely uniform prints. Critical alignment of camera and projector, and special vacuum frames which hold materials absolutely flat, are typical of the optical and mechanical features that make the Micro-Master system an engineering aid of highest quality.

No Distortion in Blow-Backs

Maximum reduction or enlargement for Micro-Master 105mm is 10 diameters —not up to 30 diameters as with smaller negatives. Thus, when drawings as large as 40 by 60 inches are reduced or enlarged, they retain a clear, sharp quality — even in the corners. There is no distortion or loss of detail, for all Micro-Master reproductions are made inside the photographic "quality barrier" of 10 diameters. Projection prints can be made on inexpensive paper as well as on cloth or film.

Like-New Prints from Worn Originals

Old originals can be restored, too — even when badly damaged. The Micro-Master process uses *reflected* rather than transmitted light. Thus, detail which has been lost through light absorption — due to dirt or discoloration — will "snap back" on the film — giving you clean prints with clear backgrounds and sharp black lines equal to ink lines. The large negative size makes it easy to see and eliminate unwanted areas by "opaquing out." Any small paint brush can be used for this purpose.

Easy to Read...Always Accessible

You can read almost every detail on a 105mm negative just by holding it up to a window or other light source. Table viewers are recommended for close study, but are *not necessary* in the "search and selection" phase. In a large plant or office, engineers can find and consult from 105mm negatives without waiting for search and delivery of originals, and without having to blow back tiny reductions to a readable size. Engineers or technicians at branch plants, warehouses or field installations can maintain compact, complete files of project information — accessible at any time without special equipment.

Easy to File, Easy to Mail

Micro-Master is a miniaturization system providing *individual* negatives that meet archival requirements. Each negative is kept in its own 5" by 8" envelope. There is ample space on the envelope for large, legible identification coding and other information. Over 12,000 drawings can be stored in a standard 5" by 8" card file cabinet. No complicated cross-indexing is needed, for negatives of original drawings and all subsequent revisions can be grouped in the same file, ready for immediate reference. The absence of sorting devices eliminates scratches and other film damage resulting from excessive mechanical handling.

See Your K&E Dealer for Information, Equipment, Service

A camera, projector, three types of viewers, and all necessary printing accessories are available with the Micro-Master system, and all equipment can be obtained through your local K&E distributor. He can also furnish 105mm reductions and enlargements of your drawings as a service. For complete information, call your K&E dealer, or write to Keuffel & Esser Co., Dept. AA-4 300 Adams St., Hoboken, N. J.

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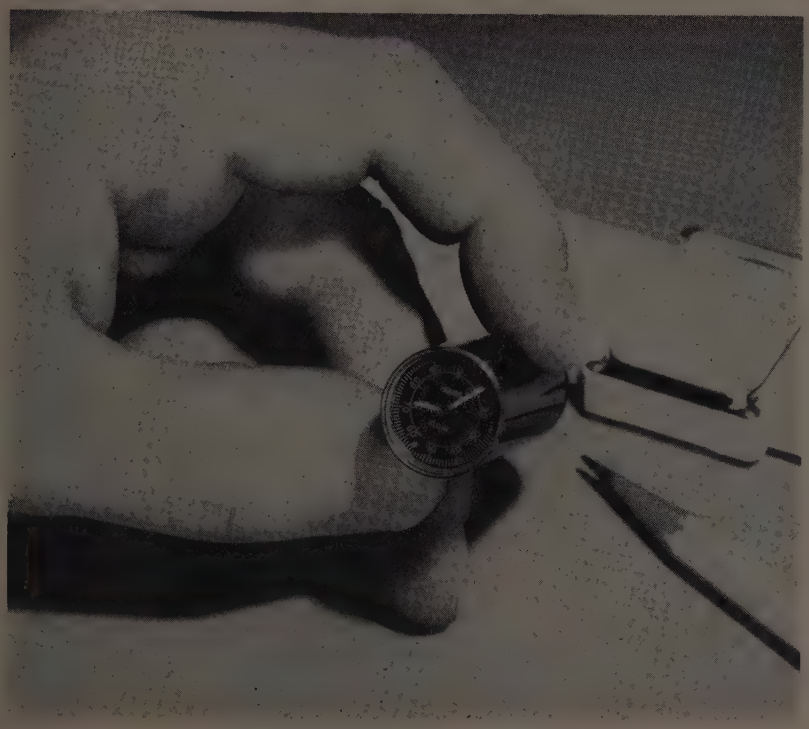
product of the month



ELAPSE TIME INDICATOR is micro-miniature

Feature Product Award

APRIL 1959

Elgin-Micronics Div., Elgin National Watch Co., Elgin, Ill., has perfected a new elapsed time indicator for measuring equipment reliability. It is 0.665 in. in diameter and 1.415 in. long and weighs 1.2 oz. It is said to be the smallest and lightest unit of its kind available today.

The indicator uses a tiny electric motor and a jeweled gear train with a 1,000,000:1 ratio to measure the time of operation of critical electronic and electromechanical devices. Capacity is up to 1000 hours. A 115 V, 400-cycle, single-phase synchronous type, it draws only 0.018 amp at less than one watt and is enclosed in a hermetically sealed case. It will stand vibration up to 10 G to 500 cps, a temperature range of —40 to +165 deg F, and shock up to 15 G. The small hand totalizes up to 1000 hours in one-hour increments, while the large hand totals up to 100 hours in one-hour increments. The running indicator is set at 50 rpm to show the totalizer is working. The indicators will cost $40 each.

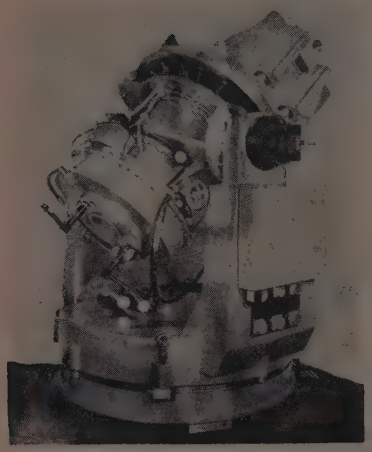
Write in No. 31 on Reader Service Card at start of Product Preview Section

This award is made in recognition of outstanding service performed through the development and manufacture of a product contributing to the advancement of aviation.

Randolph Hawthorne
Editor

product preview

TEST PLATFORM on fluid bearings



The Model T818 system test turntable is a massive, ultra-precise, tiltable, earth-axis turntable suitable for mounting complete navigation system platforms of up to 500 lb., according to **Sterling Precision Corp., Dept. S/A, 229 Binney St., Cambridge, Mass.**

The table is designed to check the alignment of inertial components and the gyro and platform drift characteristics of navigation equipment. The turntable drive is a synchronous motor at various multiples of the true earth rate. It turns precisely and smoothly on pressurized fluid bearings. The complete unit is 50 in. in diameter, 63 in. high, and weighs 7000 lb.

Write in No. 232 on Reader Service Card

GEAR PUMP designed for simplicity

Airborne hydraulic systems or industrial equipment may benefit from this low-cost, variable displacement gear pump that boasts only two major moving parts, says **Pesco Products Div., Borg-Warner Corp., Dept. S/A, Bedford, O.** The VIEP pump is particularly applicable to high-speed, elevated temperature operation.

The main pumping elements consist of an integral ring gear and pinion. An integral pressure-sensing device provides automatic pressure compensation to adjust pump displacement to variation in delivery requirements. VIEP units may be obtained for operation at speeds up to 24,000 rpm, temperatures up to 500 deg F, deliveries up to 80 gpm, and pressures up to 3000 psi. Special lightweight models are also available where exceptional high-temperature performance is not required.

Write in No. 233 on Reader Service Card

FILTERS for high frequencies

Missile guidance, telemetering and radar and navigation, among other applications, can benefit from these high-performance crystal filters, according to **Hughes Products, Dept. S/A, International Airport Station, Los Angeles 45, Calif.** The filters in the line cover center frequencies of 30 kc to 30 mc.

For example, the Type NB 1 has a center frequency of 11.5 mc, with an insertion loss at that frequency of under two db. Passband ripple is ±0.75 db. The NB 3 has a 20-mc center frequency, a three-db bandwidth of 150 kc, and a passband ripple of ±0.25. Its insertion loss at center frequency is also two db.

Write in No. 234 on Reader Service Card

DIGITAL COMPONENTS are transistorized

These basic transistorized digital computer circuit packages serve as memory units, shift registers, buffer registers, counters, and logical control units. The units include flip-flops, diode logic boards, read and write amplifiers, and blocking oscillators. Reliability is achieved in a rugged, light, small, and low-power-consuming plug-in unit, says **Computer Div., Aeronutronic Systems, Ind., Dept. S/A, Box J-486 Newport Beach, Calif.**

Each board is easily inserted or removed by means of an extended handle.

Write in No. 235 on Reader Service Card

TRANSIENT PROTECTOR for transistors

Model N 210 transistor transient protector reduces high voltage transients appearing at a normal 28-V power line. Load current up to 30 amp maximum may be passed with a voltage drop of input to output of one volt, says **Alto Scientific Co., Inc., Dept. S/A, 155 Commercial St., Palo Alto, Calif.**

The clipping level of the input spike voltage (which may be an absolute maximum of 80 V) is 35 V. The size of the unit is 2½fff2½x3½ in.

Write in No. 236 on Reader Service Card

PREAMPLIFIERS have low noise

These subminiature, broadband preamplifiers provide low noise figures of 5-8 db covering the range from 50 to 500 mc, says **The Singer Mfg. Co., Military Products Div., Dept. S/A, 149 Broadway, New York 6, N. Y.**

The unit offers a 30-db gain over an octave of frequency. Packaged power supplies are available from 60 to 400 cps ac or 28 V dc. The device —less power supply—weighs less than two pounds and measures 9x3½x2½ in.

Write in No. 237 on Reader Service Card

GEAR-TYPE PUMP handles ethylene oxide

A positive displacement, rotary, spur gear pump has been designed specifically for pumping ethylene oxide in auxiliary power package missile applications, says **Lear-Romec Div., Lear, Inc., Dept. S/A, Elyria, O.** The Model P-832B has a rating of 0.3 gpm, minimum, at an input shaft speed of 24,000 rpm, inlet pressure of 80 psig, and a pump rise of 725 psi while pumping 75-deg F ethylene oxide.

The pump features an internal cartridge, which consists of hardened steel gears running in a cast iron housing and supported by carbon journal bearings. A flexible-type seal separates the pump cartridge from the prelubricated gear section. A pressure-clamping feature has been incorporated to provide for a fixed running end clearance over the operating pressure and temperature ranges, and this creates favorable volumetric efficiencies when low viscosity fluids are handled.

Write in No. 238 on Reader Service Card

more on page 206

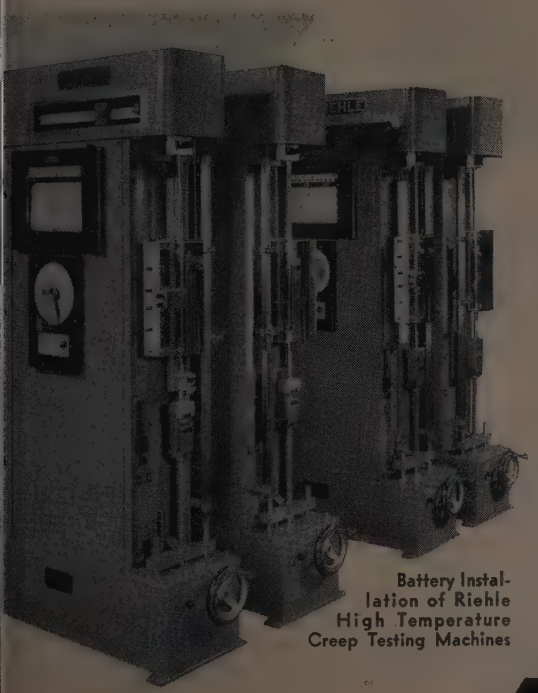
Write in No. 32 on Reader Service Card→

High temperature creep and relaxation TESTING MACHINES ... complete from RIEHLE®

New High Temperature Extensometer

iehle extensometers are available in 28 different odels to accommodate various specimens and temperures up to 3500°F. Measuring ranges are from 0.1" 0.5" and magnification ratios are from 20 to 1250, epending upon the type of recorder used.

Riehle Model MCR-20
Creep Testing Machine



Battery Installation of Riehle High Temperature Creep Testing Machines

Using only 33-1/3 lbs. of weights, this Riehle Model MCR-20 features a multiple lever loading system to provide testing loads in increments of 1,000 lbs. A sliding poise and beam graduated in units of 10 lbs. provides intermediate loads.

Riehle creep and relaxation testing machines are available in high temperature ranges of 1850°, 2200°, 3000° and 3500°F., and in capacities up to 450,000 lbs., as specially instrumented universal testing machine.

For saving time on vital projects, rely on Riehle. Contact this *one* source for ready-to-operate systems that include: (1) Basic Testing Machine, (2) Strain Measuring Instrumentation and (3) Complete High Temperature Accessories. Address DEPT. SA-459

CREEP AND STRESS RUPTURE TESTING MACHINES • HYDRAULIC FATIGUE ESTING MACHINES • HYDRAULIC UNI-SAL TESTING MACHINES • UNIVER-REW POWER TESTING MACHINES

Riehle® TESTING MACHINES

A DIVISION OF

American Machine and Metals, In

EAST MOLINE ILLINOIS

For... SILICONE FABRIC DIAPHRAGMS of aircraft and missile quality

Buy PMP!

For precision diaphragms that save time, trouble and money — look to Pacific Moulded Products

PMP silicone fabric diaphragms are precision-moulded from a variety of compounds to your specific requirements. They're completely uniform and reliable ...virtually immune to a broad spectrum of chemical and physical environments. They retain their shape and resist deterioration... can be used in many applications.

So, next time you need reliability and on-time deliveries, specify PMP!

Our field representatives will be happy to help you with your diaphragm problems.

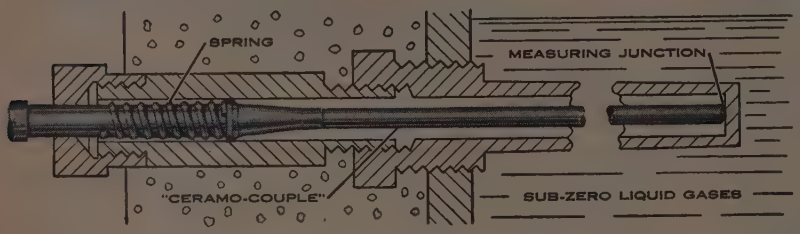
Why not call or write today to:

Pacific MOULDED PRODUCTS

PACIFIC Moulded Products
905 East 59th Street / Los Angeles 1, California
ADams 1-1151

Write in No. 33 on Reader Service Card at start of Product Preview Section

Sub-Zero Ceramo-COUPLE Solves Condensation Problems



"Ceramo" versatility has also solved a key problem of *sub-zero temperature measurement*—condensation. Caused by wide temperature differences between ambient temperatures and the thermocouple measuring point, condensation can penetrate thermocouple insulation and short out conductors.

Overall Metal Sheathing of "Ceramo" thermocouple wire completely encloses conductors and ceramic insulation—shutting out moisture effectively. Sheathing itself is stainless steel or other corrosion-resistant material.

Spring-Loaded Construction of T-E's sub-zero probe holds contact point firmly against thermowell end—counteracting effects of expansion and contraction from temperature changes.

Applications—Liquid oxygen, nitrogen, ammonia and similar applications. Conductors are either Copper-Constantan or Chromel-Constantan for measuring temperatures as low as —320° F.

Write For Bulletin 52-A

Thermo Electric CO. INC.
SADDLE BROOK, NEW JERSEY
In Canada: THERMO ELECTRIC (Canada) LTD., Brampton, Ont.

Write in No. 34 on Reader Service Card at start of Product Preview Section

TEST EQUIPMENT for waveguides

A complete line of electronic test equipment for the measurement of impedance, attenuation, and other microwave properties within the millimeter waveguide ranges is offered by **Narda Microwave Corp., Dept. S/A, Mineola, N.Y.**

Specific equipment in K-, V-, Q-, M-, and E-bands now available includes variable waveguide attenuators, tunable waveguide detectors, directional couplers, impedance meters VSWR amplifiers, terminations, E-H tuners, frequency meters, and waveguide clamps and stands.

Write in No. 171 on Reader Service Card

CHECK VALVE resists surge forces

This rugged, 1½-in. pneumatic check valve will withstand forces generated by rapidly reversing high temperature and high pressure air surges, says **Aircraft Controls Div., Barber-Colman Co., Dept. S/A, Rockford, Ill.** Maximum internal leakage is .05 lb/min at 150 psig and 800 deg F, and proof pressure is 300 psig at 800 deg. F.

The valve will withstand ten-g vibration. It is made of stainless steel and weighs .4 lbs.

Write in No. 172 on Reader Service Card

WAVEGUIDE WATERLOAD is double ridged

Model BL-570, a broad-band, power-absorbing waveguide water load, can absorb up to 4.95-10.5 kmc, says **Bomac Laboratories, Inc. Dept. S/A, 1 Salem Rd., Beverly, Mass.**

The VSWR is under 1.2 over the frequency range and represents a reflected power of under 1%. The load may be used with any water-circulating system capable of supplying about 0.3 gpm at six psig.

Write in No. 173 on Reader Service Card

more on page 208

HOW TO SOLVE AIRCRAFT AND MISSILE DESIGN PROBLEMS WITH

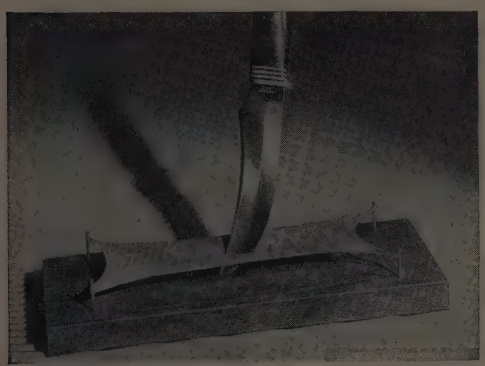
GE SILICONE IDEAS

New silicone rubber cures without heat, keeps physical and electrical properties to 600°F

Need to seal or caulk metal, glass or plastic parts? Encapsulate or pot delicate assemblies? Mold silicone rubber parts in place? Patch or repair rubber parts? Need a flexible, heat resistant, accurate, self-releasing mold for low-cost plastic tooling or model making?

New G-E RTV silicone rubber will do all this and more. Cures at room temperature in any time you select up to 48 hours. Stable up to 600°F. Excellent electrical properties. Tough, elastic, bonds well to primed surfaces. Has good resistance to aircraft fluids and fuels. Viscosities from very pourable to spreadable. Solvent free—shrinks less than 0.2% while curing. Write for technical data. Samples available for evaluation—just give us a brief description of your application.

RTV sealing in Douglas DC-8 Jetliner.



New silicone rubber shows 800% elongation, 225 lb/in tear strength, 1750 psi tensile strength.

New high strength silicone rubbers meet new, tougher specifications

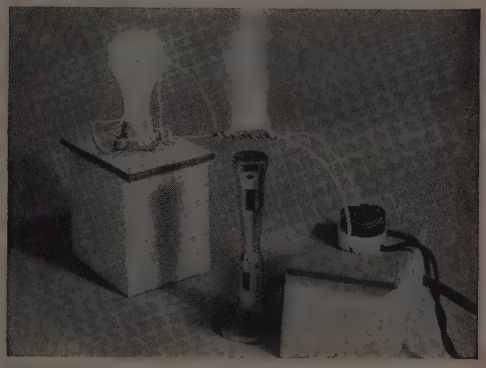
Last year G.E. doubled the strength of silicone rubber to make possible silicone parts with physical properties comparable to those of organic rubber. Since that time other improved and high strength G-E compounds have filled out the line. Now the requirements of almost any rubber application can be met without having to compromise between the temperature resistance of silicones and the physical strength of organics.

A number of new government and industry specifications have been written to take advantage of these developments. These specs, of course, are the best way for you to call for the properties you need and still give your rubber fabricator flexibility to use the newest available compounds. Write for a list of the latest specifications and data on new higher strength silicone rubber.

Better performance at 1/3 the cost . . . with new silicone rubber insulated wire

New thin wall constructions of silicone rubber insulated wire are replacing more expensive high temperature wire in many applications. Silicone rubber can withstand current overloads of 300 to 400%. The same test causes a higher priced insulation to decompose and fail.

Under emergency conditions silicone rubber gives maximum protection because it does not melt at high temperatures or give off toxic fumes—(when burned in a direct flame it forms a nonconducting ash which continues to insulate). It has outstanding resistance to temperature extremes, ozone, corona, radiation and cold flow. Excellent electrical properties are retained at elevated temperatures. Installation is easier because silicone rubber is truly flexible and strips easily. Write for complete technical data.



Silicone rubber insulated wire conducts even in an 1800°F flame.

OPERATION upturn GENERAL ELECTRIC

Send for more information.

Section D814 Silicone Products Dept.
General Electric Company, Waterford, New York

Please send me further data on

☐ Silicone Rubber Wire Insulation ☐ High Strength Rubber
☐ RTV Rubber

Name_____ Title_____

Company_____

Address_____

City_____ Zone_____ State_____

GENERAL ELECTRIC

Silicone Products Department, Waterford, New York

Write in No. 35 on Reader Service Card at start of Product Preview Section

USE THIS NEW KIND OF DIAMOND CUT-OFF WHEEL

Gives narrower, smoother cuts on industry's toughest materials

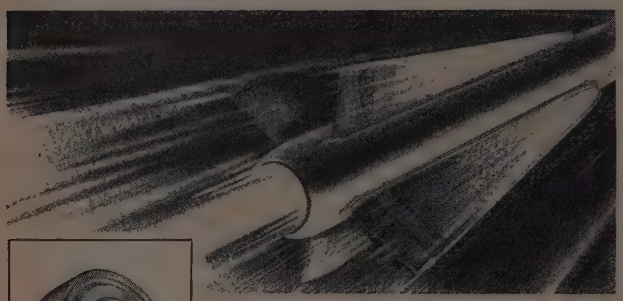
...yet prices start at only $32.25

Now... at *production prices*... DIATRONIC gives you a rim width of .006" that's accurate to a maximum total tolerance of .0005"—or your money back. This accuracy is built in by a new process. No break-in needed. New narrow cut reduces sawdust loss 30%. A must for $3,000-a-pound silicon or germanium crystal. Cuts tungsten carbide, corundum, aluminum oxide, glass... practically anything. Stock orders shipped in hours; special wheels available. Write for literature, price list.

Another invention marketed by
NAVAN PRODUCTS, INC.
Subsidiary of North American Aviation, Inc.

Dept. 171, International Airport, Los Angeles 45, Cal.

DIATRONIC* DIAMOND WHEELS
"with built-in tolerance" *TRADEMARK



Minute Giants...

B.M.B. Miniature Bearings to the highest precision limits, are made specially for Space craft, missile or ground support instrumentation.

Stainless Steel for servo applications—B.M.B. have supplied miniature bearings to the American market for the past ten years.

Miniaturization plus reliability equals faultless functioning equals B.M.B. Miniature Bearings.

AGENTS:
David R. Grossman Co., 155 East 44th Street, New York 17, N. Y. U. S. A.

Engis Equipment Co., 431 South Dearborn Street, Chicago, Illinois, U. S. A.

Manufacturing Associates, 1416 Westwood Blvd., Los Angeles 24, California, U. S. A.

BRITISH MANUFACTURED BEARINGS CO., LTD.
Sole Selling Agents:
B.M.B. Sales Ltd., High Street, Crawley, Sussex, England.
Write in No. 36 on Reader Service Card

SILICON RECTIFIERS are double-diffusion

Double diffusion processed silicon rectifiers in the Jetec series IN536 through IN540 and in the Jetec series IN2080 through IN2086 are available in the familiar, hermetically sealed, axial-lead, top-hat design, says **Columbus Electronics Corp., Dept. S/A, 1010 Saw Mill River Road, Yonkers, N.Y.**

The units achieve high rectification efficiency through a desired combination of low forward drop and low leakage currents. In addition, these devices withstand high overload currents. Other features include 500 to 750 Ma rectified current and up to 600 peak inverse volts without heat sink.

Write in No. 174 on Reader Service Card

RELAY is transistorized

The Type 160 relay is a transistorized unit that is sensitive down to two uw and that can pick up 20 uamp at 100 mv. It can be used in many applications without requiring magnetic amplifiers, according to **General Automatic Corp., Dept. S/A, 12 Carlton Ave., Mountain View, N.J.**

The transistor is self-enclosed in the relay case, and it can use external power or miniature mercury batteries in the relay enclosure. Contact capacity is one amp inductive or three amps resistive at 115 V ac or 29 V dc. Contact combinations are spst through four pdt.

Write in No. 175 on Reader Service Card

ROTARY ACTUATOR gives flight load "feel"

During flight controlled by autopilot, this actuator electrically responds to signals from the automatic pilot to justify all flight loads through the control "feel" spring. During manual control phase, the crank arm may be electrically de-clutched. When this is done, a magnetic damper, built into the actuator, eliminates oscillation as the artificial "feel" spring seeks its neutral position, says **Lyndon Aircraft, Inc., Dept. S/A, 140-15 Clifford St., Newark, N.J.**

Depending upon its application, the rotary actuator may be used to either lock the "feel" spring or allow it to come to a neutral position when the actuator is deenergized.

Write in No. 176 on Reader Service Card

CR TUBE resolves 5000 lines

The type 5/71 CM tube is a micro-spot cathoderay tube capable of resolving 5,000 lines. The spot size is less than one-thousandths of an inch in diameter, says **Ferranti, Ltd., Dept. S/A, Hollinwood, Manchester, Lancs., England.**

The tube has an optical flat face with non-darkening glass and a short cylindrical bulb, coated—except over the screen surface—with a thick layer of plastic resin, enabling it to be operated under adverse atmospheric conditions, viz. 30 KV at 75,000 ft. without danger of e.h.t. breakdown.

Write in No. 177 on Reader Service Card

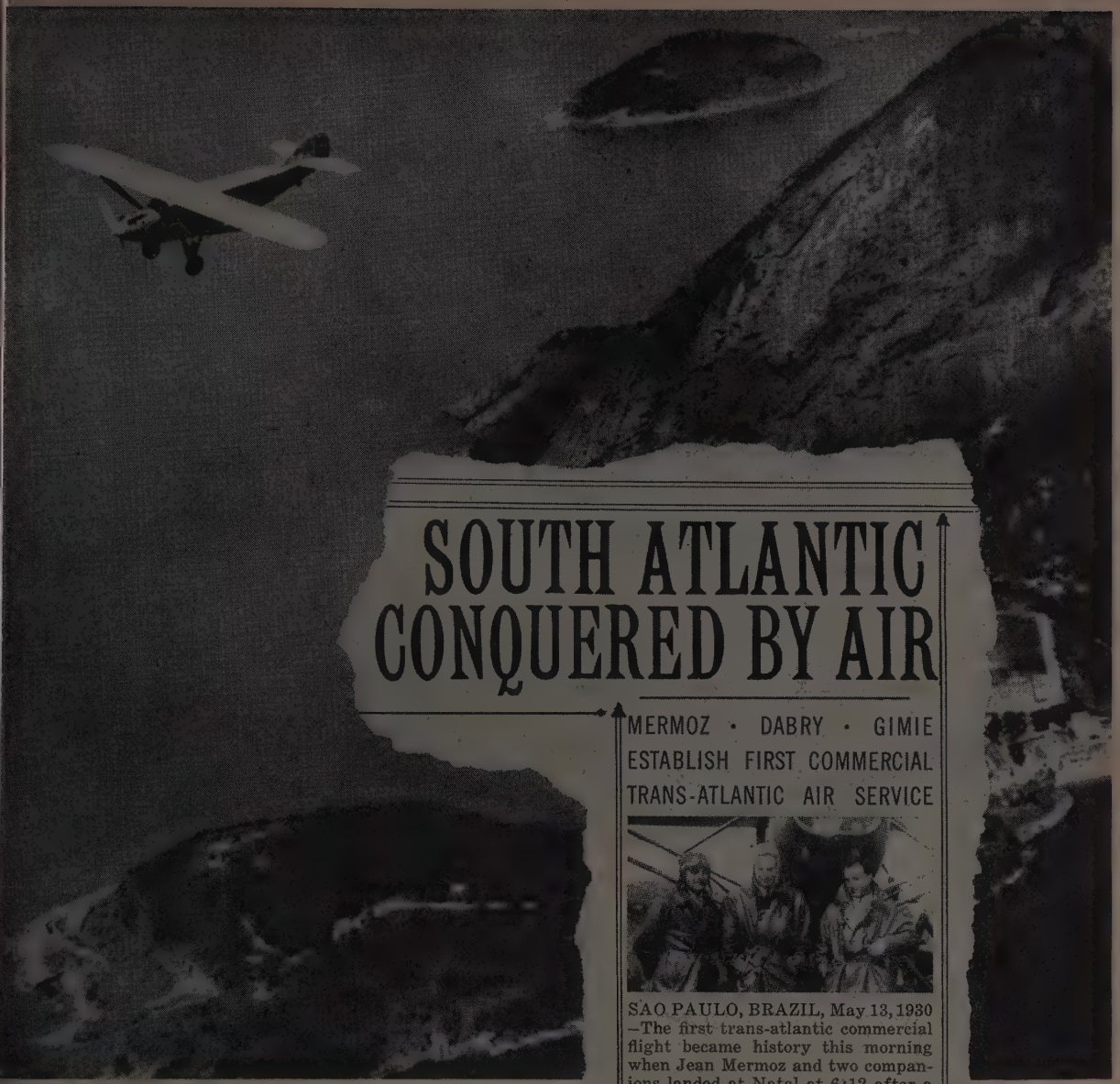
CHOPPER has no moving parts

This miniature, all-electronic chopper with no moving parts has a minimum operating life of 5000 hr. according to **Kearfott Co., Inc., Dept. S/A, 1378 Main St., Clifton, N.J.** While its primary use is as a dc-to-ac converter that is sensitive to the phase of the reference voltage, it can also be used as an ac-to-dc convertor.

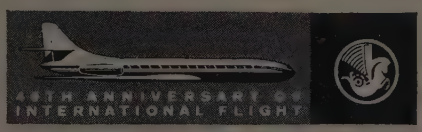
The 333058 chopper features a frequency range of 60 cps to 20 kc, 180 deg dwell time, and zero phase shift. Used as a modulator, it has a reference power of 6.3 V at 2 ma, a load resistance of 1000 ohms to one megohm, and a dc signal input of one mv to five V. Load current is five ma maximum.

Write in No. 178 on Reader Service Card

more on page 210


SOUTH ATLANTIC
CONQUERED BY AIR
MERMOZ · DABRY · GIMIE
ESTABLISH FIRST COMMERCIAL
TRANS-ATLANTIC AIR SERVICE
SAO PAULO, BRAZIL, May 13, 1930 —The first trans-atlantic commercial flight became history this morning when Jean Mermoz and two companions landed at Natal at 6:12 after a flight of 20 hrs. and 16 minutes from St. Louis, in Senegal, Africa. The intrepid French fliers were eagerly awaited in Rio de Janeiro

FIRST IN INTERNATIONAL AIR TRAVEL! This year marks Air France's 40th Anniversary as the world's first international airline. During these 40 years, there have been many changes in equipment, routes and airline philosophy. But one thing remains constant. Air France still follows the great tradition of French leadership in aviation. That's why this year, when other airlines are making plans, Air France is making history with the fastest jets in Europe and the Middle East. Next year, Air France will cover the world's largest route network with one of the largest pure-jet fleets in the world.



AIR FRANCE

WORLD'S LARGEST AIRLINE/WORLD'S FIRST INTERNATIONAL AIR SERVICE

Write in No. 37 on Reader Service Card at start of Product Preview Section

HARCO

a PROVEN source

OF FIBERGLASS CONTAINERS AND INTEGRAL GROUND HANDLING TRAILERS

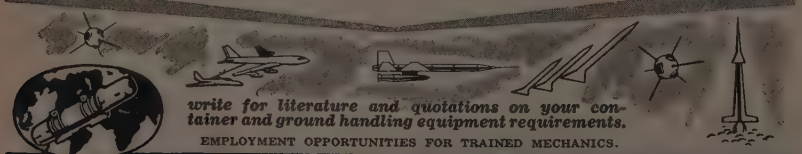
LOADED CONTAINERS
Measuring 18½' long, 4½' diameter and weighing up to 4800-pounds when loaded with in-flight refueling stores and integral trailer, can be stacked 3 high to conserve storage space.

FAST UNLOADING OF REFUELING STORES
Less than 60-seconds required to remove end sections, through use of unique Vee-band clamps, greatly speeds unloading of stores on integral ground handling Harco trailer.

TRAILER IN PLACE FOR RETURN TO BASE
Harco Containers are a complete system for storage, transport and ground handling of critical stores; important part of system is Harco developed trailer which is returnable within container for re-loading.

END SECTIONS REVERSED FOR RETURN SHIPMENT
Overall length is reduced by half for empty-return shipment, conserving valuable shipping space. Use of fiberglass reduces container weight by 60%; is impervious to rust or corrosion; easily repaired in the field.

Harco Containers are the **only** fiberglass containers for storage, transport and handling of in-flight refueling stores approved by BuAer. Features include 60% reduction in weight, reversible end sections to cut return shipping size by ½, integral ground handling trailers for stores, 60-second availability of stores through use of quick release Vee-bands on end sections. Two years of field service prove their superiority. Other Harco Containers available for missiles, jet engines, re-fueling system components, electronic equipment.



write for literature and quotations on your container and ground handling equipment requirements.

EMPLOYMENT OPPORTUNITIES FOR TRAINED MECHANICS.

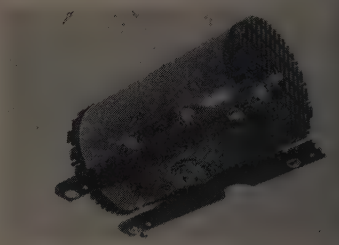
Harco Containers

A DIVISION OF HARBOR BOAT BUILDING CO

258 CANNERY STREET, TERMINAL ISLAND, CALIFORNIA

Write in No. 38 on Reader Service Card at start of Product Preview Section

POWER SUPPLY eliminates transients



Model 6073 transistorized power supply provides built-in protection against spikes and transients as well as input polarity reversal and short circuits, says **Universal Transistor Products Corp., Dept. S/A, 17 Brooklyn Ave., Westbury, N.Y.** Operating efficiency is 87%.

The unit produces 300 V dc and 100 V dc from a 27V dc input. The supply operates at temperatures from —40 to +80 deg C. Size is 6¼ in. by 3½ in. diameter. Weight is 2¾ lb. Other models are available with inputs from six to 110 V dc and outputs to 2000 W.

Write in No. 179 on Reader Service Card

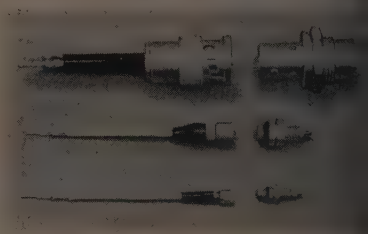
EPOXY COATING is flexible

Type PRH 400 is a solvent-based epoxy system for use as a protective coating with printed circuits as well as plastics, ceramics, and metal, says **Permacel, Dept. S/A, New Brunswick, N. J.**

The coating can be applied by dip-brush or spray methods and will cure at room temperature. It consist of a 60% solid solution of resin and a 60% solution of hardener. Shelf life is one year.

Write in No. 180 on Reader Service Card

COAXIAL CONNECTORS are subminiature



These connectors are 1/25th the overall size of a standard BNC connector, with 1/50th of the weight, says **Microdot, Inc., Dept. S/A, 220 Pasadena Ave., South Pasadena, Calif.**

The connector has recently passed extensive tests for vibration, VSWR, and pullout and insertion.

Write in No. 181 on Reader Service Card

more on page 214

Space Technology Laboratories is responsible for the over-all systems engineering, technical direction and related research for the Air Force Intercontinental and Intermediate Range Ballistic Missile Programs and for the highly successful Thor-Able series of ICBM range re-entry launches. ■ In addition, STL carries out special experimental projects for such agencies as the National Aeronautics and Space Administration and the Advanced Research Projects Agency. On behalf of these agencies and in conjunction with the Air Force Ballistic Missile Division, STL designed and produced the Pioneer I payload, one of the most sophisticated fact-finding devices ever launched into space. In addition, STL provided systems engineering and technical direction for the Air Force satellite, the Atlas SCORE. ■ In support of these and future requirements, STL's activities provide a medium through which scientists and engineers are able to direct their interests and abilities towards the solution of complex space age problems. STL invites inquiries regarding staff openings in any of the five major areas of the company's activities.

Electronics Laboratory
...provides technical direction for, and conducts studies leading to, design and specifications of advanced guidance, control, and communication systems; also packaging, environmental testing and over-all checkout.

Physical Research Laboratory
...conducts basic research including analytical and experimental investigations in magnetohydrodynamics, thermonuclear power, plasma physics, and low temperature solid state physics.

Astrovehicles Laboratory
...conceives, evaluates, designs, develops, and tests space vehicle systems; provides technical direction of propulsion, nose cone, and airframe subsystems; explores new propulsion, airframe, re-entry, and ground handling techniques.

Computation & Data Reduction Center
...provides a centralized mathematical and computing facility and engages in advanced research in data systems, information theory, computation systems and automatic programming, systems and hardware simulation, and applied mathematics.

Systems Engineering Division
...has the over-all responsibility for the system integration of the Atlas, Titan, Thor, and Minuteman weapons systems, in addition to responsibility for technical direction of the airframe, sub-system, assembly and test, and ground support activities; evaluates proposed future weapons and space systems.

Space Technology Laboratories, Inc., P. O. Box 95001, Los Angeles 45, California

custom-designed Lord mounting systems for:

assure:

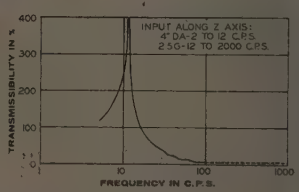
positive protection for sensitive equipment

The mounting system shown here was designed, developed and produced by LORD for the inertial guidance platform of an ICBM. It clearly demonstrates LORD's capability to meet the most sophisticated requirements for shock and vibration protection.

You can assure optimum reliability for your missile or advanced jet project by utilizing LORD skills and experience. Integration of LORD abilities with those of your staff will result in an economical system design providing maximum protection for given weight and size.

Complete research, engineering, test and production facilities—staffed with personnel of outstanding capabilities—can provide vital assistance for your program. Full information is available from your nearest LORD Field Engineer or the Home Office, Erie, Pennsylvania.

High-performance mounting system protects 180-lb. guidance platform against ICBM environment. Highly original design weighs only 18 lbs., uses Lord BTR elastomer for broad temperature operation.



LORD

FIELD ENGINEERING OFFICES

ATLANTA, GEORGIA - CEdar 7-9247
BOSTON, MASS. - HAncock 6-9135
CHICAGO, ILL. - Michigan 2-6010
DALLAS, TEXAS - Riverside 1-3392
DAYTON, OHIO - BAldwin 4-0351
DETROIT, MICH. - Diamond 1-4340
KANSAS CITY, MO. - WEstport 1-0138
LOS ANGELES, CAL. - HOllywood 4-7593
NEW YORK, N. Y. - Circle 7-3326
PHILADELPHIA, PA. - PEnnypacker 5-3559
SAN FRANCISCO, CAL. - EXbrook 7-6280

"In Canada—Railway & Power Engineering Corporation Limited"

LORD MANUFACTURING COMPANY • ERIE, PA.

Write in No. 39 on Reader Service Card at start of Product Preview Section

THE REQUIREMENT:

To design and build a quick-check, highly accurate, dual system, portable pneumatic test bench for sensing and locating air leakage in the canopy seal and cabin/cockpit of pressurized aircraft.

THE EQUIPMENT:

The SUN Model SX-106, Air Leakage Cabin/Cockpit Pressure Tester. Comprising two separately controlled pneumatic systems, operating from a common 100 psig shop air source, this unit provides a dynamic air flow of 200 SCFM with a pressure load up to 15 psig. Static pressure may be regulated up to 30 psig. Simple controls and instrumentation relate air temperature, pressure and true flow reading to pounds per minute air loss.

THE BUILDER:

The Aeronautical Division of Sun Electric Corporation — one of the foremost experienced designers and producers of aeronautical and missile testing and support equipment. For any problem involving electrical, electronic, hydraulic, pneumatic, or related equipment, you'll save time AND money by consulting Sun's Engineers FIRST!

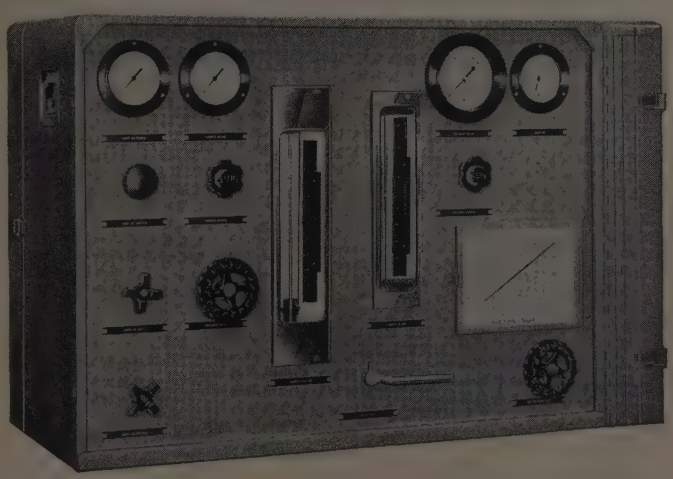
GENERAL SPECIFICATIONS

Length 38½ inches
Height 28½ inches
Depth 22½ inches
Weight 290 pounds

Operating Range:
40°F to 120°F at 80 psig

High and Low Range Flowmeters — 20 to 200 SCFM and 2.9 to 29 SCFM ±2% full scale

Internal pressure relieving components protects aircraft against over-pressurization.



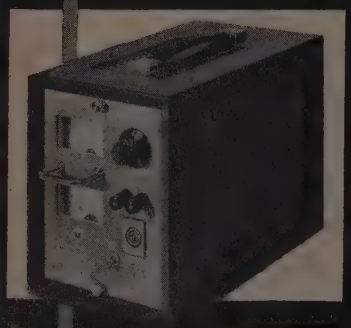
Model SX-106 Aircraft Cabin/Cockpit Air Leakage Tester.
All connections between tester and aircraft made at rear of unit.

Sun ELECTRIC CORPORATION

AERONAUTICAL DIVISION • HARLEM AND AVONDALE • CHICAGO 31, ILLINOIS

Write in No. 40 on Reader Service Card at start of Product Preview Section

Absolute
ISOLATED DC POWER SOURCE



for

RESISTANCE-TYPE TRANSDUCERS
STRAIN GAGES
ACCELEROMETERS

Now for the first time you can have the dependability and ease of operation of an electronic power supply *plus* the isolation normally obtained only from a battery. The Moeller Model 21 Power Supply exclusively provides *absolute isolation from line voltage and line ground.*

The Model 21 provides 0-20 volts, 1 amp of power for strain gages and resistance-type transducers. This transistorized instrument gives improved performance with existing single-ended and differential amplifiers and offers voltage regulation, internal impedance, ripple and stability equal to, or superior to, conventional transducer power supplies.

Write for descriptive literature.

MOELLER
INSTRUMENT CO.
ELECTRONICS DIVISION
132nd Street & 89th Avenue
Richmond Hill 18, N. Y.

Write in No. 41 on Reader Service Card

SELECTOR VALVE *is fast, dependable*

A four-way, solenoid-operated, pneumatic selector valve that features extremely rapid and dependable operation over a wide range of operating pressures is available from Tactair Valve Div., Aircraft Products Co., Dept. S/A, 300 Church Rd., Bridgeport, Pa.

The Tactair Model 9801 has a pressure range of 500 to 3000 psi from sea level to 70,000 ft, a flow capacity of 0.2 Qu for its light weight and small size, a low external leakage of three cc/hr max, and an operation time of 0.05 sec max to energize.

Write in No. 182 on Reader Service Card

more on page 216

Matching GEARMOTORS . . .

Three-stage gearmotor incorporates special brackets, reversing switch and connecting cord for pipe threader.

Differential planetary gear train allows for unusually compact design in miniature gearmotor for business machines.

Six-pole 400 cycle AC gearmotor for operating tap-changing switch.

For Your Power-Driven Products

Lamb Electric gearmotors designed to functionally match your product, provide the important requirements of:

- *low speed*
- *high torque*
- *compactness*
- *dependability*
- *low weight*
- *favorable cost*
- *improved product appearance*

Our manufacturing facilities enable us to build the complete range of sizes and types of hobbed and shaped gears for use with fractional horsepower motors.

Many years of specialized experience in this field, combined with the finest gear cutting and testing equipment, assure unexcelled performance in Lamb Electric gearmotors.

NEW! 8-page Folder describes these and other Lamb motors. Send for your copy.

THE LAMB ELECTRIC COMPANY • KENT, OHIO
A Division of American Machine and Metals, Inc.
In Canada: Lamb Electric—Division of Sangamo Company Ltd.—Leaside, Ontario

Lamb Electric
SPECIAL APPLICATION FRACTIONAL HORSEPOWER **MOTORS**

Write in No. 143 on Reader Service Card at start of Product Preview Section

He's getting results...

WITH THE NEW BRUSH RECORDER MARK II

So can you. The versatile Mark II is an integrated oscillograph package—a readout tool for engineers and technicians everywhere . . . in the shop . . . in the lab . . . or in the field.

Just plug it in . . . put it to writing . . . anywhere.

PERFORMANCE SPECIFICATIONS

Recordings—Uniform, crisp, easily reproduced. Trouble-free ink writing on precision chart paper.

Channels—Two analog, plus two event markers.

Sensitivity—Maximum of 10 mv/chart line (mm); range, 10 mv to 400 v.

Input—Differential; impedance 5 megs each side to ground.

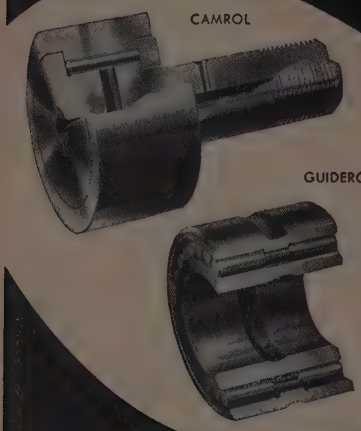
Frequency Response—D.C. to 100 cps.

Write for free booklet 2521A for complete specifications. Immediately available from stock. Price $1350, f.o.b. Cleveland, Ohio

brush INSTRUMENTS
DIVISION OF
37TH AND PERKINS CLEVITE CORPORATION CLEVELAND 14, OHIO

Write in No. 42 on Reader Service Card at start of Product Preview Section

McGILL
CAMROL and GUIDEROL
bearings



...add dependability to ground support equipment

High capacity in limited space plus precision accuracy make these bearings ideal for use as track, guide and support rollers in missile and rocket ground support equipment.

CF SERIES CAMROL bearings feature an integral stud and heavy duty outer race. They eliminate the cost of building up improvised bolt and roller units and withstand the shock of heavy loading. Also available with seals and pre-lubricated.

GR SERIES GUIDEROL bearings provide full complement roller capacity with self-guided rollers for true-running trouble-free performance. SG SERIES sealed GUIDEROL bearings are also available for applications where contamination must be sealed out and lubrication sealed in.

For data on the complete line of McGill Bearings, send for Catalog No. 52A

engineered electrical products
McGILL®
precision needle roller bearings

McGILL MFG. CO., INC., Bearing Division
621 N. Lafayette St., Valparaiso, Indiana
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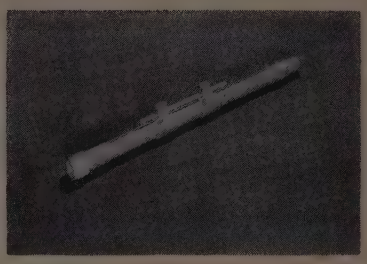
DOUBLE SLUG TUNERS for microwaves



These coaxial double slug tuners cover the frequency range from 300 to 5000 mc. The separation of two slugs mounted in a 50-ohm transmission line may be adjusted and locked, according to **Microlab, Dept. S/A, 71 Okner Pky., Livingston, N. J.**

The tuners are available for standing wave ratios of less than 2:1 and 10:1. They are part of a line that includes constant-impedance line stretchers, trombone line stretchers, and double stub tuners.

Write in No. 183 on Reader Service Card

LOX PUMP is lightweight

An electric motor-driven, two-stage centrifugal pump for liquid oxygen and liquid nitrogen had been developed by **The J. C. Carter Co., Dept. S/A, 671 W. 17th St., Costa Mesa, Calif.** It is said to be particularly suited to installations requiring a lightweight, compact design.

The device will deliver 60 gpm against a 550-ft head.

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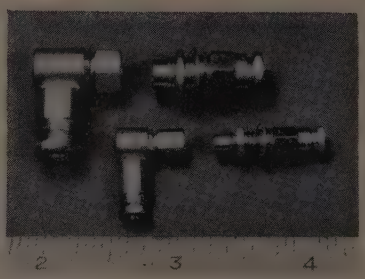
R F CABLE CONNECTORS in 75- and 95- ohm series



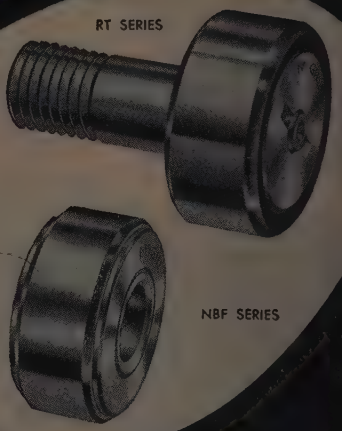
ConheX RF cable connectors in 75- and 95-ohm series have been added to the original 50-ohm series available from **Sealectro Corp., Dept. S/A, 610 Fayette Ave., Mamaroneck, N. Y.**

The units offer easy assembly and increased pullout resistance and will withstand over 25 lb strain. Parts are machined brass, except for the female contacts, which are made of heat-treated berryllium 25.

Write in No. 185 on Reader Service Card

more on page 220

McGILL
Aircraft
needle bearings



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Full complement needle bearing capacity, precision accuracy to NAS and AFBMA standards, non-separable construction, lightweight and high material selection standards qualify MCGILL RT, NBF, NBL and NBC bearings for aircraft cam, track, and guide roller applications. Surfaces plated as required.

RT and HRT SERIES—for use when a cantilever type stud mounting is required. Plating or surface treatment and lubrication holes supplied as application dictates.

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NBC SERIES — for applications where bearing O. D. can be supported in a housing. Suitable for slow rotation and oscillation.

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McGILL MFG. CO., INC., Bearing Division
621 N. Lafayette St., Valparaiso, Indiana
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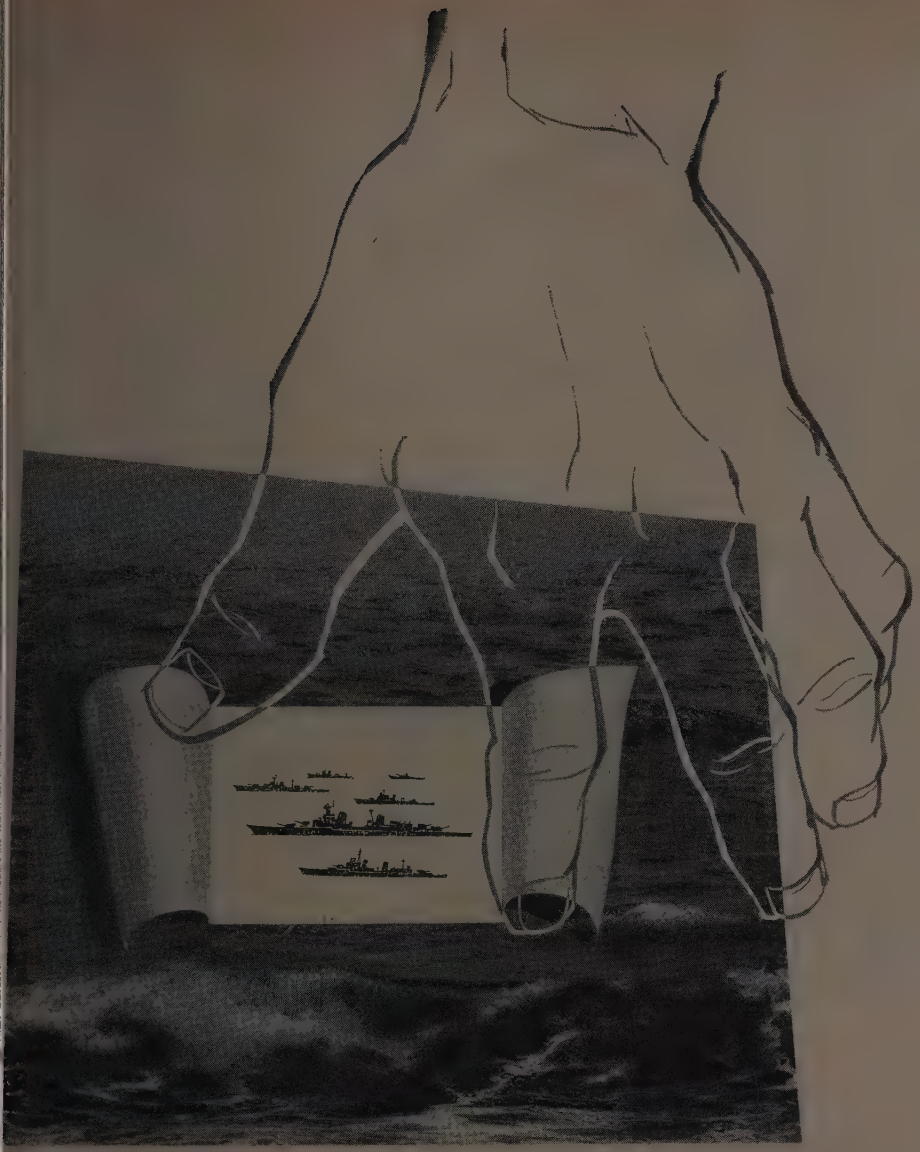

IR

Today the Singer Manufacturing Company's Military Products Division is performing a substantial role in basic research and development, engineering and production of infrared systems and components. This is just one of many ways in which the Military Products Division—composed of H.R.B., Inc., Diehl Manufacturing Company, and Bridgeport—is now serving national defense. Write for complete details.

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measure control... without contact...

Now—measure pressure, temperature, vibration . . . any physical quantity you can convert to a change in capacitance . . . without fuss, muss, or bother. Decker's Delta Unit takes the output from the simplest △ capacitance sensors you can devise, converts it to an analagous phase sensitive differential DC voltage for indication and recording.

The new 902-1 Delta Unit is based on Decker's patented T-42 Ionization Transducer. It provides all the advantages of the T-42 ready to use in a simple, compact package as versatile and flexible as your own imagination.

Accepting initial capacitances from 1 to 50 μμF, the 902-1 provides maximum signals of ±30 VDC. Sensitivity in the 5-20 μμF initial capacitance range is approximately 0.2V/% △ C. Unit is provided with a single measuring probe and cable assembly; however, two measuring probes may be operated simultaneously. Complete information is provided in Instrument Data Sheet 902-1, available on request.

THE DECKER CORPORATION *Bala Cynwyd, Pennsylvania.*

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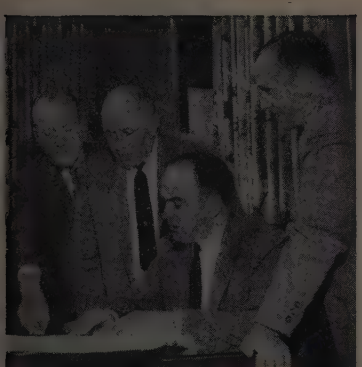
In Customer Service—meet a man who gets results

This General Mills executive-in-the-field comes to lighten your load



No matter where your plant or office is located, one of these General Mills regional managers is nearby to serve you promptly and efficiently. Left to right:
R. N. Norgaard—*Eastern Regional Mgr.*
L.G. Hocraffer—*Central Regional Mgr.*
W. M. Hilt—*Mid-central Regional Mgr.*
D. J. Owen—*Western Regional Mgr.*

If any one could possibly take the same personal interest in your highly complex research, engineering and manufacturing assignments as you do, this is the man. He is the voice of General Mills management in your area. Service is his job. He will give you accurate, useful information about Mechanical Division capabilities in advanced areas relating to military systems and sub-systems. He will show you ways in which you can best utilize these capabilities—often at a considerable saving in time and dollars. And he will follow through on your product assignments as if they were his own, making doubly sure that specifications are adhered to, that production moves ahead as planned, that deliveries are made on schedule. Service is his job. And that's another good reason our customers say, "At General Mills we get results."

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RELAY
has no moving parts

The electronic coil circuit operates on 28 V dc, pulls in at 18 volts, and drops out at 7 volts or less with a positive snap-action operation. The coil circuit is completely isolated from the electronic switching circuit, making one coil circuit capable of switching many independent circuits within one unit, says **Pendar, Inc., Dept. S/A, 2664 S. LaCienega Blvd., Los Angeles, Calif.**

The relay is completely potted and will withstand any shock or vibration problems. The unit will switch either ac or dc and has a transfer time of less than 50 microsec and no contact bounce.

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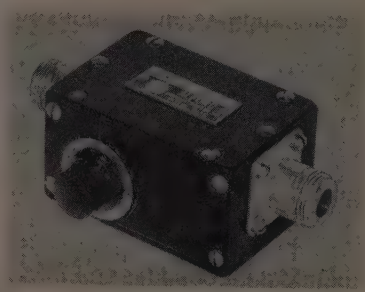
MATCHING NETWORK
is adjustable



The AMCI Easymatch is an adjustable matching network for VHF-UHF frequencies. It is used to change an approximate match into an accurate one, says **Alford Mfg. Co., Dept. S/A, 299 Atlantic Ave., Boston 10, Mass.**

The input impedance varies slowly with frequency; nominal impedance is 50 ohms. Four ranges of frequency are available: 45-85 mc, 85-150 mc, 150-300 mc, and 300-700 mc. Units in each range will match any 1.1:1 mismatch regardless of phase.

Write in No. 187 on Reader Service Card

TERMINAL BUSHING
is snap-in receptacle

An insulated, miniature, Nylon receptacle has been designed to provide quick connect and disconnect access through housings, without pig-tail wire leads or screw terminals, says **Heyman Mfg. Co., Dept. S/A, Kenilworth, N. J.** The Heyco junction terminal bushing may be used for electronic and electrical circuits, and components such as motors and control devices.

The color-coded bushing is snap-anchored into a suitable chassis hole. Brass terminals for the bushing are available in solder, crimp and double disconnect types. The terminals are snap-fastened into the bushing.

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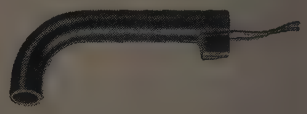
more on page 222

CHROMALOX
FLEXIBLE AND MOLDED
ELECTRIC HEATERS

Electronic heating harness molded to fit small object. Three woven heaters molded in high temperature refractory and aluminum case (left) and glass and polyester resin (center and right). Small thermostat is molded to base of center heater.

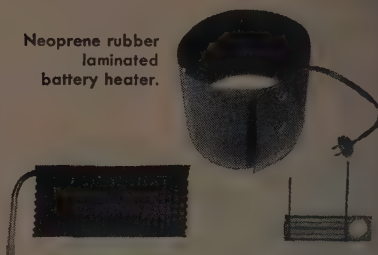


Neoprene rubber molded heater, eliminates ice clogging of aircraft pitot tube.

Silicone rubber laminated heater molded on a 2½" spherical radius. Two of these completely cover and protect guided missile storage battery reservoir.

Silicone rubber laminated heater capsulates liquid oxygen valve in guided missiles.

Silicone rubber laminated heater bonded to a metal component for an aeronautical camera.



Neoprene rubber laminated battery heater.

Woven heaters. Temperatures to 800°F. Any size or shape up to 24" wide and to any length. Can be supplied with eyelets, snap fasteners, mounting holes. Moisture and abrasion resistance can be provided by silicone rubber coating.

Chromalox Flexible and Molded Heaters are shaped-to-fit to put exact amounts of heat where it is needed.

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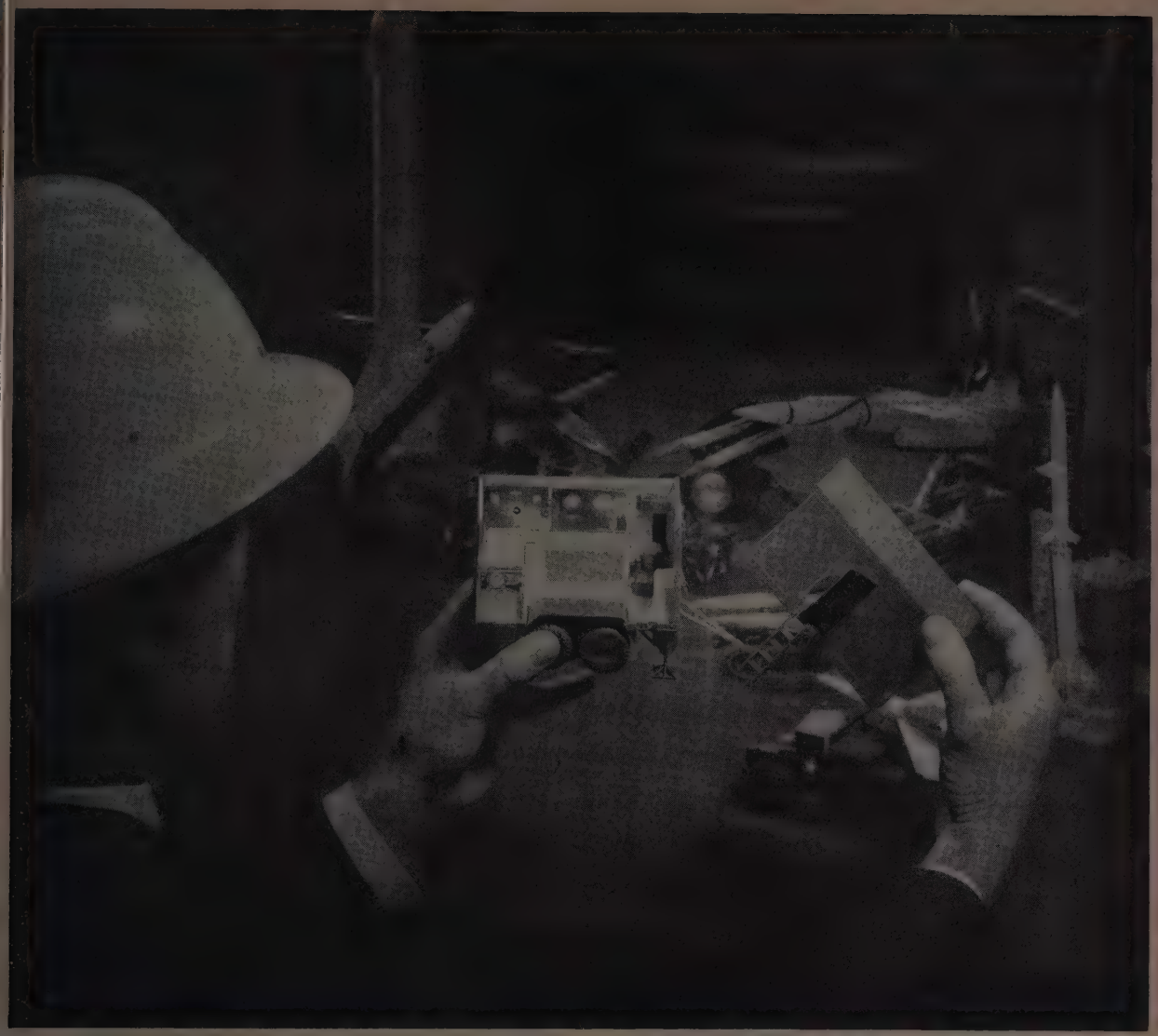

UAP offers complete responsibility for system simulators in "hard-hat" areas

Many of today's missiles carry vital operational components made by United Aircraft Products, Inc. Research, development and manufacture of these components, backed by over 30 years of supplying parts and systems to all major aircraft manufacturers, have furnished UAP with broad experience. This includes electronics, electronic cooling, mechanical and electro-mechanical devices, hydraulics, pneumatics, fuel systems, cryogenics and other specialized functions. UAP can meet strictest government requirements... has skilled engineers and modern production facilities to carry through on assigned projects.

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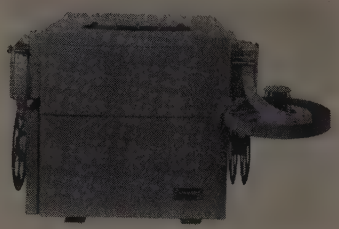
TRANSMITTER-RECEIVER for long-range data



A machine for sending, receiving, and checking data encoded in more than five channels of punched paper tape over existing wire services has been announced by **Friden Calculating Machine Co., Inc., Dept. S/A, San Leandro, Calif.** The Friden Teledata has the ability to transmit a greater number of code combinations as well as to check the accuracy of transmission, over any commercial telegraph channel. Various other channels of communication can also be used, such as telephone circuits and microwave systems.

The unit is capable of transmitting and receiving five, six, seven, and eight channel tape. Two or more units are stationed at different locations providing a means for immediate communications. The machines have a tape reader and a punch. The reader, located at the right of the unit, is in operation when sending or transmitting information. The punch, on the left, is in operation when receiving information.

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COLD CABINET for testing to —150 deg F

A sub-zero testing cabinet called zerolab, function-tests a wide range of electronic, aircraft, missile, metal, rocketry, radio and other components. Items of metal, rubber, plastic, glass and other materials are easily tested for abilities to withstand extremes of vibration and sub-zero temperatures that go down —150 deg F, says **C. T. C. Manufacturing Corp., Dept. S/A, 11936 Valerio St., No. Hollywood, Calif.**

The zerolab, Model 101, is entirely self-contained, having a two-stage freezing system powered by two five h.p. compressors. It is equipped with an observation window in the top and other openings on the front permit the attachment or insertion of wiring, cables, thermocouples and vibration-testing devices.

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more on page 224

Get
FULLY AUTOMATIC PRODUCTION OF FINISHED WIRE LEADS

. . . any operator can produce 3,000 or more leads per hour in any insulated wire to 10-ga.

END wire stripping bottlenecks! You can measure, cut off and strip insulated wire with this *fully automatic* ARTOS machine . . . over 6,000 leads per hour with some types of wire.

With unskilled labor, solid or stranded wire leads are produced in lengths from 2" to 194"—and stripped up to 2" at one or both ends.

ARTOS MODEL CS-6

(Left) AE-563 PREFEEDER

Completely automatic, self-adjusting unit with ⅓ hp. motor. Requires no attention after wire has been threaded into stripping machine. Heavy reels roll into cradle or can be mounted on a shaft.

ALSO AVAILABLE: Extra equipment to mark leads with any code. Other machines also attach prefabricated terminals in strip form to your wire leads.

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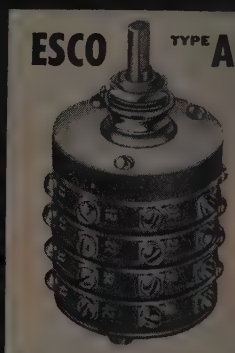
rotary multipole switch



meets Specification MIL-S-6807

- *8 contact positions.*
- *Up to 6 sections, or poles.*
- *Unlimited or limited rotor movement by moving two stop screws.*
- *Electrical ratings: 5 amp. 28 v. d-c, resistive. 2.5 amp. 28 v. d-c, inductive. 2.0 amp. 28 v. d-c, lamp load. 5.0 amp. 115 v. 400 cps, resistive. 2.0 amp. at 50% power factor.*

The ESCO Type AF rotary multipole tap switch is designed to meet Specification MIL-S-6807. Rotor movement can be changed from unlimited to limited (2 to 8 positions) by placement of two stop screws at the rear plate.

Write today for Bulletin 7.

ESCO of WEYMOUTH
ELECTRO SWITCH CORPORATION
Weymouth 88, Massachusetts

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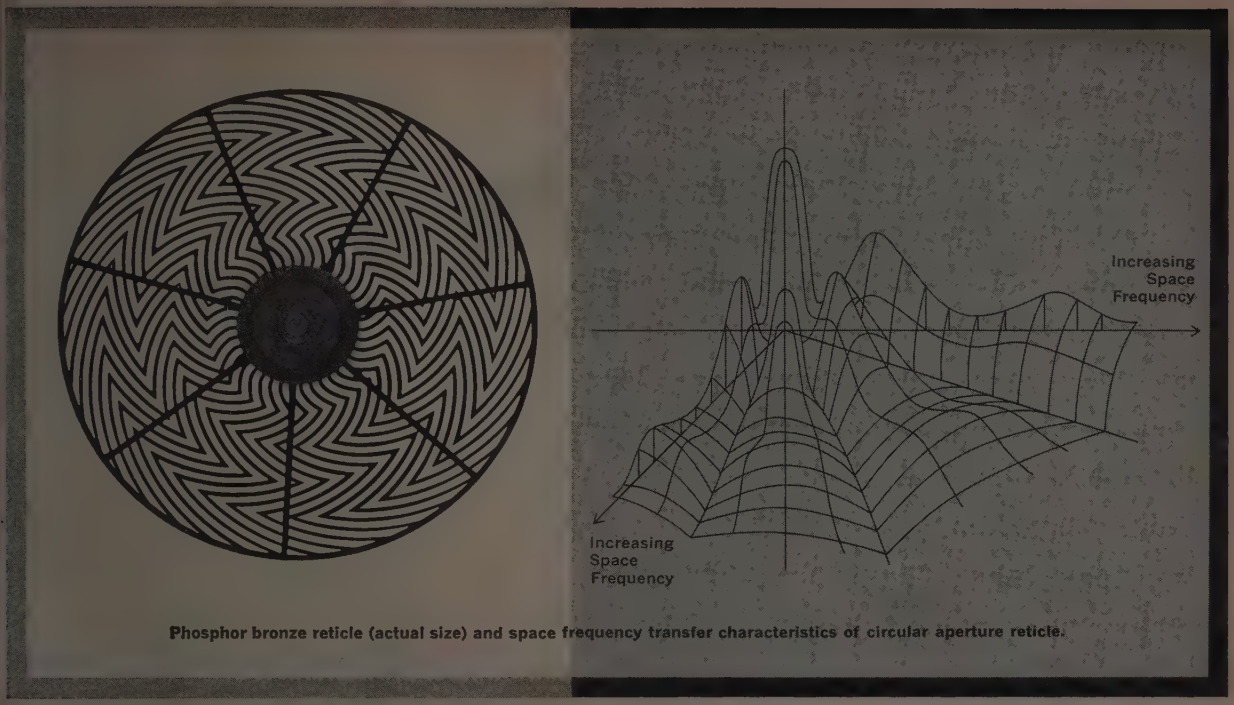

Phosphor bronze reticle (actual size) and space frequency transfer characteristics of circular aperture reticle.

TARGET DISCRIMINATION IN INFRARED DETECTION SYSTEMS

The pioneering field of infrared detection offers many challenging opportunities to scientists and engineers at Ramo-Wooldridge for advanced studies in the solution of target discrimination problems. Research is continually under way at Ramo-Wooldridge in the integrating of infrared detection devices with the latest electronic systems techniques for enhanced target detection on the ground and in the air.

The phosphor bronze reticle, or image chopper, illustrated above was developed by Ramo-Wooldridge. It indicates a marked stride in space filtering discrimination concepts, and is used for target signal enhancement in guided missiles, anti-aircraft fire control and air collision warning applications.

The reticle is used in the focal plane of an infrared optical system and is rotated to chop the target image for the desired space filtering. It is also employed in time filtering, such as pulse length discrimination, or pulse bandwidth filtering.

Space filtering is critical to infrared systems, because of its ability to improve the detection of objects located in the midst of background interference. In a manner similar to that used in the modification of electronic waveforms by electrical filtering, space filtering enhances the two-dimensional space characteristics of a target. The size and features of the target are highlighted and the undesired background eliminated.

Scientists and engineers with backgrounds in infrared systems—or any of the other important areas of research and development listed below —are invited to inquire about current opportunities at Ramo-Wooldridge.

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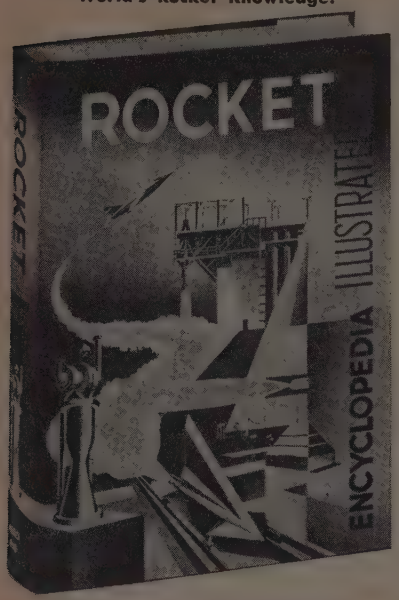

ROCKET ENCYCLOPEDIA ILLUSTRATED

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EMITTER FOLLOWER is subminiature

Model 5000, solid state emitter follower unit, has an input impedance of 70 megohms and operates over temperatures from −6 to +185 deg F under high noise and shock conditions, says **Columbia Research Labs., Dept. S/A, MacDade Blvd. & Bullens Lane, Woodlyn, Pa.**

Measurements from 5 cps to 100 kc with crystal type accelerometer can be made and the output noise characteristics are such that signals in the low millivolt region may be handled. Output is linear over a 20 volt input range and the circuit draws about 669μa from a 28 Vdc supply. It provides a current gain of 50,000 and a voltage gain of 0.99. Other models are available with a continuously variable voltage gain to 100. The unit measures 1⅛x1¼x ⅝ in.

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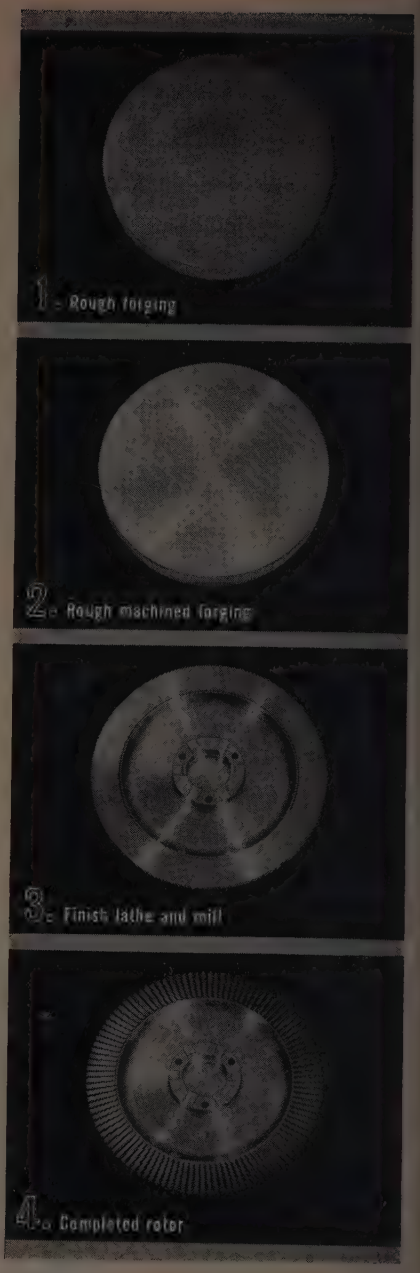
TACH GENERATOR is high temperature unit

An operating temperature range of −55 to +125 deg C has been designed into a Size 8 servo motor tach generator by **Avionics Div., John Oster Mfg. Co., Dept. S/A, 1 Main St., Racine, Wis.** The Type 8MTG-6202 which has a rotor moment of inertia of 1.15 gm cm² and weighs 3.1 oz, meets the environmental requirements of Mil-E-5272A.

The device has a no-load speed of 6500 rpm and a generator output of .25 V per 1000 rpm. The two-phase motor has 26-V excitation on Phase One, and a 30/15-V center tap control on Phase Two. Stall power input is 3.0 W per phase, and torque at stall is 0.3 oz-in. The linearity rating is ½ per cent to 4000 rpm, and the phase shift is zero deg, plus or minus ten deg.

Write in No. 192 on Reader Service Card

more on page 226



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to your precise specification

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- Designed to MIL-E-5272.
- Assembled under closely controlled environmental conditions.

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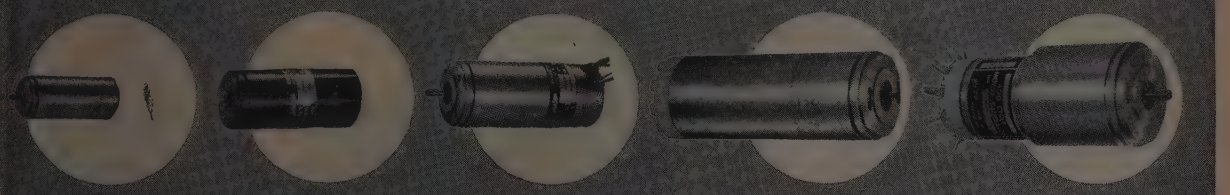

400 CPS SERVO MOTOR—TACHOMETER GENERATORS

Oster Type	Size	Length Inches	Wt. Oz.	Rotor Inertia gm cm²	MOTOR					GENERATOR				
					Rated Voltage		No load speed RPM	Watts per phase @ Stall	Stall Torque OZ. IN.	Excit. Volt.	Output Volts per 1000 RPM	Lin.% to 3600 RPM	Null MV	Phase Shift @25°C
					Ø 1	Ø 2								
8MTG-6201-01	8	1.850	2.3	0.77	26	40/20	6,500	2.2	0.16	26	0.25	0.5	15	± 5°
[illegible]	10	2.157	4.2	0.72	115	115/57.5	9,500	2.8	0.26	115	0.45	1.5	19	±10°
[illegible]	10	2.100	2.9	1.09	33/16.5	52/26	9,500	3.0	0.28	26	0.45	1.5	13	±10°
[illegible]	10	2.100	2.9	1.09	26	26	10,500	3.0	0.26	18	0.3	1.5	12	±10°
10MTG-6229-15	10	2.100	2.9	1.09	26	26	10,500	3.0	0.26	26	0.3	1.5	12	±10°
*10MTG-6232-05	10	2.104	4.2	1.1	115	36/18	6,500	3.5	0.26	115	0.30	1.5	15	±10°
11MTG-6251-13	11	2.531	7.0	1.3	115	115/57.5	6,500	3.5	0.63	115	0.55	0.5	19	±10°
[illegible]	11	2.531	7.0	1.1	115	40/20	6,500	3.5	0.63	115	0.55	1 5	19	±10°
[illegible]	11	2.200	6.0	1.1	115	115/57.5	6,500	3.5	0.63	115	0.55	1.5	19	±10°
[illegible]	15	3.281	14.0	5.3	115	115/57.5	5,000	6.2	1.5	115	3.0	0.2	13	± 5°
†*15MTG-6276-03	15	3.875	15.0	4.4	115	57.5	8,500	5.8	0.70	115	2.75	0.2	13	± 0.5°
[illegible]	18	3.680	20.0	5.7	115	115/57.5	9,000	16.0	2.7	115	3.0	0.2	13	± 5°
18MTG-6302-04	18	3.680	20.0	5.7	115	115/57.5	4,800	9.2	2.4	115	3.0	0.2	13	± 5°

*These units designed for 85°C ambient but same characteristics can be designed for 125°C. †Additional 21.4 watts for heater, the values given are independent of ambient temperature.

Other products include servos, synchros, resolvers, motor-gear-trains, AC drive motors, DC motors, servo mechanism assemblies, reference and tachometer generators, servo torque units, actuators and motor driven blower and fan assemblies.

John Oster MANUFACTURING CO.
Your Rotating Equipment Specialist
Avionic Division
Racine, Wisconsin

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Engineers For Advanced Projects: Interesting, varied work on designing transistor circuits and servo mechanisms. Contact Mr. Robert Burns, Personnel Manager, in confidence.

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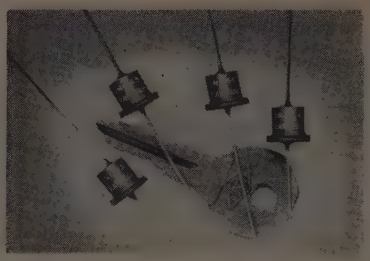

Types 1N1763 and 1N1764 silicon rectifiers are of the wire-in construction type, are small in size, and are suitable for high temperatures, says Raytheon Mfg. Co., Technical Information Service, Dept. S/A, 55 Chapel St., Newton 58, Mass.

SILICON RECTIFIERS for high temperatures

Type 1N1763 has a peak inverse voltage rating of 400 volts and a dc load current rating of 500 ma at 25 deg C. The ratings for 1N1764 are identical except for a 500 volt peak inverse.

Write in No. 193 on Reader Service Card

more on page 228

Special Mention For Efficiency Under Stress: Roebling, The U.S. Civilian Aircord

Roebling Aircord—tinned or galvanized carbon steel—comes to you bearing an unparalleled "research pedigree." It is built and tested to exceed *military* specifications: constructional stretch has been virtually eliminated. Roebling makes Lock-Clad Aircord (aircraft cable with aluminum tubing swaged around it), stainless steel aircord, assemblies with fittings swaged to cable ends, as well as a complete line of slings.

Plane manufacturers and air supply houses interested in the qualities of Roebling aircord assemblies or slings, may address inquiries to Wire Rope Division, John A. Roebling's Sons Corporation, Trenton 2, N. J.

ROEBLING

Branch Offices in Principal Cities
Subsidiary of The Colorado Fuel and Iron Corporation

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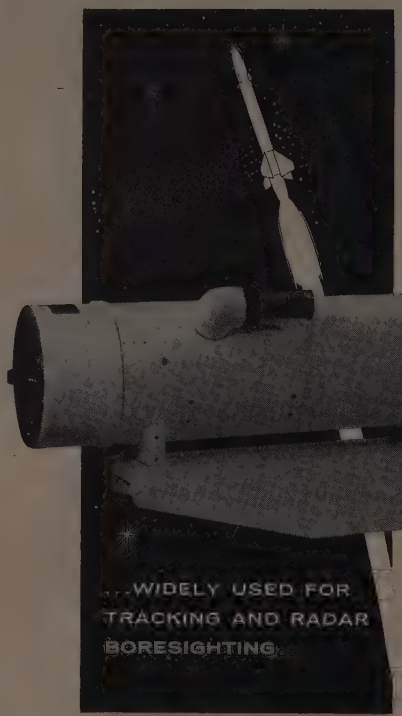

oh say can you see?

"FAR-SIGHTED" MIRROTEL LENSES CAN

Wollensak Mirrotel Lenses (20", 40" and 80") extend the capabilities of high speed motion picture photography in tracking missiles and in radar boresight applications. They deliver images of excellent resolution and contrast.

ADVANTAGES • Because of mirror optics (the light path is "folded" three times within the system) the lenses are short and lightweight . . . are free from chromatic aberration, coma, astigmatism, distortion . . . are most stable under extreme environmental conditions. Invar rod mounting permits high boresighting accuracy.

CAMERAS • Mirrotel lenses are extensively used with a wide variety of cameras, such as FASTAX, FASTAIR, Flight Research IV-C, Automax, Mitchell (16mm, 35mm), Cameraflex, Eyemo and TV cameras.

SPECIAL FEATURES • Mirrotel Lenses can be supplied with reticle printers, fiducial markers, continuous focusing, counters, reflex finders, radiation shields, custom mounting bases for lens and camera (illustrated), neutral density and color filters.

If you need extra long focus lenses of unusual characteristics, **WRITE** Dept. FXL for Mirrotel catalog M-1 and prices. Inquiries invited.

FOR THE FINEST IN PHOTOGRAPHY THE WORLD OVER • IT'S WOLLENSAK •

WOLLENSAK

OPTICAL COMPANY • ROCHESTER 21, N. Y.

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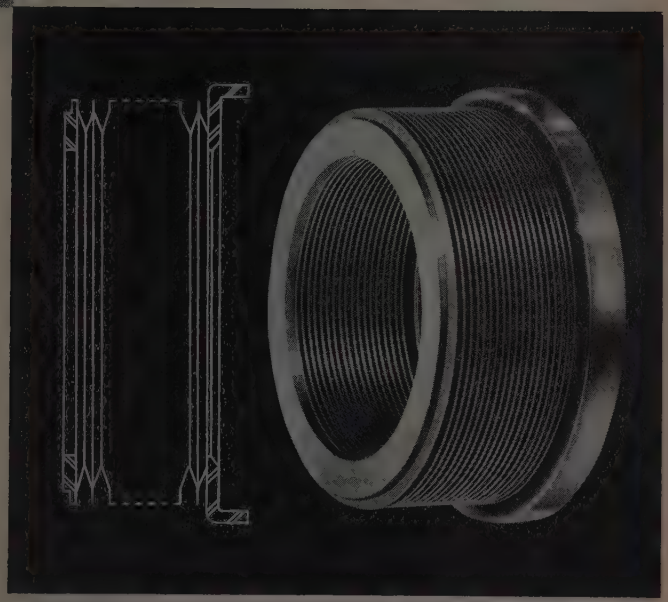
C/R DESIGN NOTES

How C/R's New Metal Bellows Seal Meets Seemingly Impossible Operating Conditions



Operating Ranges

Temperature	—400° to 1000° F.
Pressure	500 psi
R.P.M.	80,000 plus

These known operating ranges indicate the function of this seal. It is designed for applications where temperatures and mediums to be sealed forbid the use of any organic materials. Typically, these applications include fuel pumps, compressor power units and turbine starters characteristic in rockets and missiles. Other applications include mechanisms which are exposed to a high level of radioactivity.

Design Advantages

The C/R metal bellows seal consists of a metal bellows — a welded homogeneous unit which is secured at one end — and a carrier ring in which the sealing face is mounted. The seal does not contact the shaft. It is stationary, and the only rubbing surfaces are the sealing face and mating ring. These surfaces are precision lapped to provide a positive seal with minimum friction. At any given pressure, the seal can be designed to maintain proper and constantly effective face loads. It orients immediately to run-out and will resist any torques it is subjected to in operation. The design has high end-play tolerance: Chicago Rawhide engineers have deflected a bellows .100 in. for three million cycles at 1750 cpm and at a temperature of 500° F. with no adverse effects.

A further advantage is relatively light weight and compactness. The C/R metal bellows seal can be designed for minimum axial and radial space. Axially, complete seals can be produced within a ¼ in. cross-section. Radially, dimensions are comparable with conventional end face seals.

The C/R metal bellows seal can also be designed with an extremely low coefficient of expansion. The importance of this factor becomes apparent with the fact that in many applications the operating temperature may change hundreds of degrees in a very few seconds.

Mediums To Be Sealed

Virtually any known liquid or gas may be positively sealed with this design, depending upon duration or service life. From a practical viewpoint, the C/R metal bellows seal is the best design for the sealing of cryogenic and high-energy fuels such as LOX, hydrogen peroxide, fluorine and other missile and rocket propellants.

Where possible, lubrication of the two sealing faces is desirable to prolong service life. However, the medium being sealed commonly acts as the lubricant and may be merely hot gas.

Materials

Sealing faces and mating rings for the C/R metal bellows seal are available in a variety of materials including carbons, carbides, ceramics and various alloyed metals for both high temperature and corrosion resistance. The bellows can be furnished in any of several metals and alloys such as stainless steel, Monel, Inconel X, Ni-Span C and other special alloy steels.

Consult C/R Engineers

Each application for the C/R metal bellows seal is essentially a custom-design and an intimate knowledge of all conditions to be encountered must be known by Chicago Rawhide engineers to produce the correct combination of properties in the seal. Then, whether you require five, fifty or five thousand seals, Chicago Rawhide will design and produce the correct seal to solve your problem.

Helpful Design Data:

We will gladly furnish you with a design guide and space envelope data concerning the C/R Metal Bellows Seal. Just write for Bulletin MBS-1 on your company letterhead.

CHICAGO RAWHIDE MANUFACTURING COMPANY

1293 Elston Avenue • Chicago 22, Illinois

Offices in 55 principal cities

In Canada: Chicago Rawhide Mfg. Co. of Canada, Ltd., Brantford, Ontario

Export Sales: Geon International Corp., Great Neck, New York

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ETALON
INGAGE
measures the exact BORE or blind hole size!
Reading: .0001"
Size 3/16" to 4"
Takes accurate measurements of blind holes. No masters or setting rings—measures directly—by .0001".
Automatic alignment, rectangular contact points guarantee extreme accuracy even when fully extended. Immediately detects out of round holes, with extensions measures holes up to 6 feet deep. Hardened contact points exert minimum pressure—will not damage fragile work.
Easy to read, deep graduations on a large diameter thimble. Dull chrome plated. Furnished in English or Metric graduations, individually or in sets.
WRITE FOR CATALOG on complete line of precision measuring instruments: VERNIER CALIPERS, MICROMETERS, DIAL INDICATORS.
ALINA
ALINA CORPORATION
172 East Second St.
Mineola, L. I., N. Y.

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HEAT RADIATOR for transistors

Model 3B-663 is a heat dissipation device designed for diamond-shape power transistors. The radiator reduces temperature of transistors as much as 30 deg C under typical operating conditions, says the Birtcher Corp., Industrial Div., Dept. S/A, 4371 Valley Blvd., Los Angeles 32, Calif.

The device meets the requirements under Mil-E-5272A and Mil-STD-202A. The radiator consists of a series of black ebanol finished metallic radiating fins mounted on a base plate, between the transistor and the chassis.

Write in No. 194 on Reader Service Card

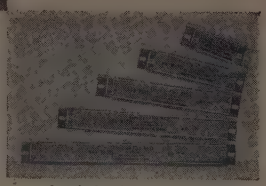
more on page 232

New
POWER RESISTORS
for FLIGHT USE

ELECTRO-FLEX
specialists in HEATING ELEMENTS

LESS SPACE—LESS WEIGHT

New lightweight, space-saving resistors permit substantial efficiencies and economies in aircraft and missile electronic apparatus. Units are mounted in direct contact with inner surface of chassis or case so that 25% to 40% of heat generated is emitted to atmosphere. Derating curves are available.



Available in the following ratings and sizes

Power Rating	Envelope Dimensions	Approx. Weight
40 Watts	7/32 x 1 5/16 x 4	.027 lbs. ea.
80 Watts	7/32 x 1 5/16 x 6	.040 lbs. ea.
120 Watts	7/32 x 1 5/16 x 8	.053 lbs. ea.
160 Watts	7/32 x 1 5/16 x 10	.067 lbs. ea.
200 Watts	7/32 x 1 5/16 x 12	.080 lbs. ea.

Insulation is silicone rubber—operable continuously at 450° F.
Mounting metal—Alclad aluminum.
Connection tabs—silver plated brass.

Special washers permit bolt or rivet mounting. Adhesive supplied provides good thermal transfer from resistor to mounting wall.

send for free illustrated booklet

Electro-Flex Heat, INC.

83 WOODBINE ST., HARTFORD, CONN. (CHapel 6-5413)

"FIRST with STANDARD ELEMENTS"

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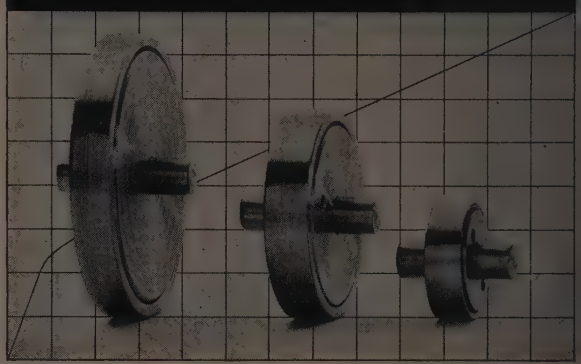
MINIATURE ROTARY POSITIONING CONTROLS



Inch Ounces to 65 Inch Lbs.—Precisely, positively held in an infinite number of positions. Clockwise or counterclockwise rotation. No backlash. Low breakaway torques. Vibration proof. Applications include no-back, potentiometer positioner, dial control, clutch, coupling, etc. Patented principle. Diameters ¾" to 1¾". Depth 5/16". We'll gladly send literature.

REID CONTROLS
Reid Metal Products, Inc.
2021 W. Lincoln St., Burbank, Calif.

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Mission: **LUNAR PROBE**

Filter application: **PROTECT HYDRAULIC CONTROLS**

Filter choice: **PUROLATOR**

Complex, "must-succeed" filter applications in Atlas and other top priority projects are some of the tough new space-age filtration problems our engineers have solved. Your call or letter will put their unique experience and production facilities at your disposal, to help you develop ways of handling your own aircraft and missile filtration requirements.

Filtration For Every Known Fluid

PUROLATOR

PRODUCTS, INC.

Rahway, New Jersey and Toronto, Ontario, Canada

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IT'S ALWAYS "WINTER" *SOMEWHERE*

Heating Blankets and other Woven Heating Elements by SAFEWAY can make your COLD problems OLD problems!

To keep sensitive equipment, fuels, propellants and lubricants at correct operational temperatures in any cold environment, controlled heat must be delivered with utmost dependability. SAFEWAY delivers it — *everywhere.*

Among the wide variety of heating blankets and woven-wire heating elements successfully engineered by SAFEWAY to meet tailor-made specifications are:

- **heating blankets for honeycomb and metal-to-metal bonding**
- **de-icing units for airfoil surfaces**
- **heating elements for launching equipment and for airborne gyros, cameras, computers, servos and batteries — for missiles or aircraft**
- **radiant heating panels for industry**
- **defrosting units for industrial and commercial refrigeration**

FOR YOUR COPY OF A FACT-FILLED FOLDER, PLEASE WRITE:

If it has to be heated (and the "it" can be just about anything), you can rely on SAFEWAY engineers to study your problems and — without any obligation — submit an appropriate recommendation.

Safeway HEAT ELEMENTS INC.

680 Newfield Street • Middletown, Connecticut

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A 3M Case History Report

DEBURRING-POLISHING TIME CUT 40% WITH "PG" WHEELS

MANUFACTURER: LeTourneau-Westinghouse Company

ADDRESS: Peoria, Illinois

PRODUCT MANUFACTURED: Earth Moving Equipment

3M ABRASIVE USED: "PG" Wheels

HOW 3M ABRASIVES ARE USED: "PG" Wheels used for contour polishing of air brake backing plate. Malleable cast-iron plate requires super-smooth finish on two concentric rings, to provide air-tight seal against neoprene air diaphragm.

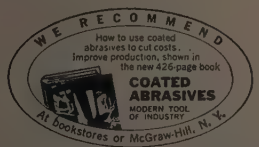
OPERATIONAL DATA ON 3M METHOD: Two 1" x 10" "PG" Wheels, Grit #150 Three-M-ite Resinbond Cloth, mounted side-by-side on shop-made polishing shaft uniformly deburr and polish plate ring surfaces in 2-3 minutes.

OPERATIONAL DATA ON PREVIOUS METHOD: Overall deburring and polishing was by hand-rubbing with emery cloth. Time required was 4-6 minutes per plate.

PROVEN ADVANTAGES OF 3M METHOD: "PG" Wheel method, as opposed to hand finishing, allows more uniform finishing as abrading pressure can be more constantly applied with machine. Average time saving of 40% realized.

WANT MORE INFORMATION? Send for free manual, "Modern metal finishing with 3M 'PG' Wheels." Write to 3M Co., St. Paul 6, Minn., Dept. TU-49.

"PG" Wheels are manufactured in U.S.A by 3M Company, St. Paul 6, Minn. Export: 99 Park Avenue, New York. Canada: London, Ontario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How to use coated abrasives to cut costs. Improve production, shown in the new 426-page book
COATED ABRASIVES
MODERN TOOL OF INDUSTRY
At bookstores or McGraw-Hill, N. Y.

3M Coated Abrasives

"PG" WHEELS

MINNESOTA MINING AND MANUFACTURING COMPANY

...WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY

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Photo courtesy of Trailmobile, Inc.

UNITED MOBILITY ARMS THE MARTIN MATADOR

United Caravan Axles are engineered to meet the most stringent military specifications. Caravan axles are a part of Military ground support handling equipment all over the world.

United works in fullest cooperation with its customers to supply a product that meets Military Specifications. Hubs, wheels and spindles are manufactured to Military Specifications such as MIL-W-8005 and others. United Caravan Running Gear can be supplied to meet all mobility requirements of MIL-M-8090 and other military specifications.

The newly developed lightweight United Air Flite Unit, is designed and engineered for greater and more versatile performance and has been approved through military testing.

Write today for the new illustrative United Catalog.

THE UNITED MANUFACTURING COMPANY
5250 Dobeckman Avenue • Cleveland 2, Ohio

At United there is No Substitute for the Design and Manufacture of a Superior Product

West Coast Division: The United Caravan Axle Co. 1326 N. Tyler Ave., El Monte, Calif., Gilbert 3-4153

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ADHESIVE
bonds most materials

Almost any combination of materials can be joined in a high-strength bond by 910 adhesive, according to **Eastman Chemical Products, Inc., Dept. S/A, 260 Madison Ave., New York 16,, N.Y.** The bond is achieved without the need for excessive pressure, heat, solvent evaporation, or long curing time.

The material is said to be solving production assembly problems and making possible design innovations suited to production line techniques for the first time.

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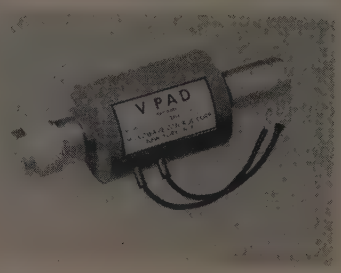
ATTENUATOR
electronically variable



This broadband coaxial V PAD attenuator is electronically variable from 10 to 25 db. The variation is continuous, being a function of solenoid current, with the maximum attenuation needig 30 ma at S-band and 70 ma at X-band, according to **Microwave Control Corp., Dept S/A, 250 W. 57th St., New York 19, N. Y.**

The small, light unit has a low VSWR and no moving parts. Being electric, the device also serves as an amplitude modulator for microwave RF. Other models are available with attenuation as low as three decibels over the 2-10-kmc range.

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SILICONE RUBBER
is quick-setting

Silastic RTV 502 is a fluid material that, at room temperature, vulcanizes to a rubber in 30 min—about 20 times faster than conventional RTV silicone rubbers, says **Dow Corning Corp., Dept. S/A, Midland, Mich.** The material can be used for sealing and caulking metal-to-metal and metal-to-rubber joints, for potting, as a mold, and as a shock and vibration absorber.

It remains flexible over a —70 to +500 deg F range, and it has good insulating properties. It will resist weathering, moisture, ozone ,and corona.

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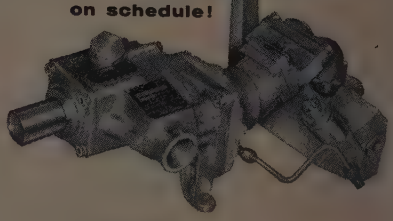
more on page 234

Simple or Complex
FROM JUST A SPEC

MC • DESIGNS • PRODUCES • DELIVERS on schedule!



RELIABLE at every step

In this package MC has condensed many functions:

Solenoid, pilot, two speed 24 GPM Valve, 3000 psi motor, relief, filters, restrictors, timers, bypasses, manual modulating override gears, two output shafts 8000 RPM.

Send your inquiries for hydraulic, pneumatic and fuel components to

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P.O. Box 126 • LAKE ORION, MICH.

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Authenticast
MINIATURE MILITARY MODELS

UNUSUAL — PRECISION DETAILED

The complete AUTHENTICAST line of missiles, tanks and military vehicles is one of the most exceptional sets of scaled models ever created. Made from actual government blueprints to exact specifications, they are authentic right down to the last rivet. These models are cast in metal with precision accuracy - every tiny detail is distinctly depicted. U.S., British, German, Russian and Japanese Tanks, Ships and Planes are included in this fabulous collection.

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CANADIAN
MARCONI
COMPANY

THE WORLD OVER
KLM
ROYAL DUTCH
AIRLINES

AIRBORNE Doppler NAVIGATION SENSORS

CMA-620 SERIES

Now adopted by KLM Royal Dutch Airlines for their Douglas DC8 jet airliner fleet

Special features incorporated in this equipment provide automatic memory, continuous and automatic total system check in flight and high sensitivity over water.

Full details and technical description available on request.

Produced in accordance with Arinc Doppler Radar characteristic 540.

CANADIAN MARCONI COMPANY
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2442 TRENTON AVENUE, MONTREAL 16, CANADA

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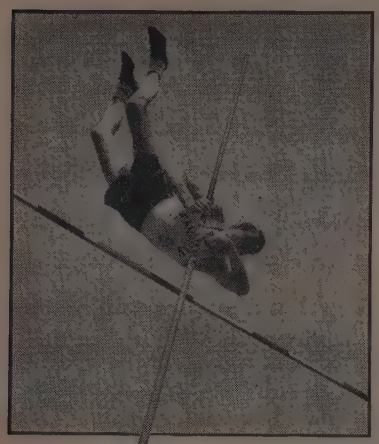
TOPS 'EM ALL



IN QUALITY OF TUBING

Comparative quality tests by one of America's leading users of tubing proved only Precision Tubing rates excellent in all specifications . . . yet Precision Tubing costs no more.

Precision Tubing is unequalled and unsurpassed in quality tests of accuracy, temper, straightness and roundness. You are sure of extra quality in every size tube at regular mill prices. Available in sizes from .010" to 1.125" O.D. in copper, brass, aluminum, up to 5/8" O.D. in nickel and nickel alloys, Ni-Span "C", phosphor bronze and nickel silver. In straight random lengths, coils or preformed shapes to specifications.

Write for catalog and technical data to Dept. 9, Precision Tube Company, Inc., North Wales, Pa.

GET THIS NEW TUBING DATA CATALOG

PRECISION TUBE COMPANY

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FILTER is reject

A wide-band tunable reject filter in coaxial line for the 2-4 kmc frequency range uses a single micrometer knob to reject any frequency in this range to about 30 db with less than 1 db loss at non-resonant frequencies, says **Radar Design Corp., Dept. S/A, Picard Dr., Syracuse 11, N. Y.**

The company says its filter uses a new principle—the resonant hybrid approach.

Write in No. 198 on Reader Service Card

AIR CONDITIONER is compact

This very compact air conditioning unit can be used in support vans for electronic equipment or personnel, says **C. G. Hokanson Co., Inc., Dept. S/A, 2140 Pontius Ave., Los Angeles 25, Calif.** The 70-in.-high unit was originally designed for the Thor missile support system.

It is rated at four tons and 48,000 BTU/hr, and it can maintain temperatures from 50 to 90 deg F with an air capacity of 1000 cfm.

Write in No. 199 on Reader Service Card

VARIABLE AIR CAPACITOR is subminiature

The type U subminiature air capacitor requires less than 0.2 sq in. for chassis or panel mounting. Rotor and stator are machined from one piece of solid brass, providing outstanding mechanical stability and uniformity, says **E. F. Johnson Co., Dept. S/A, Waseca, Minn.**

All metal parts are silver-plated. Ceramic is steatite, Grade L-4 or better.

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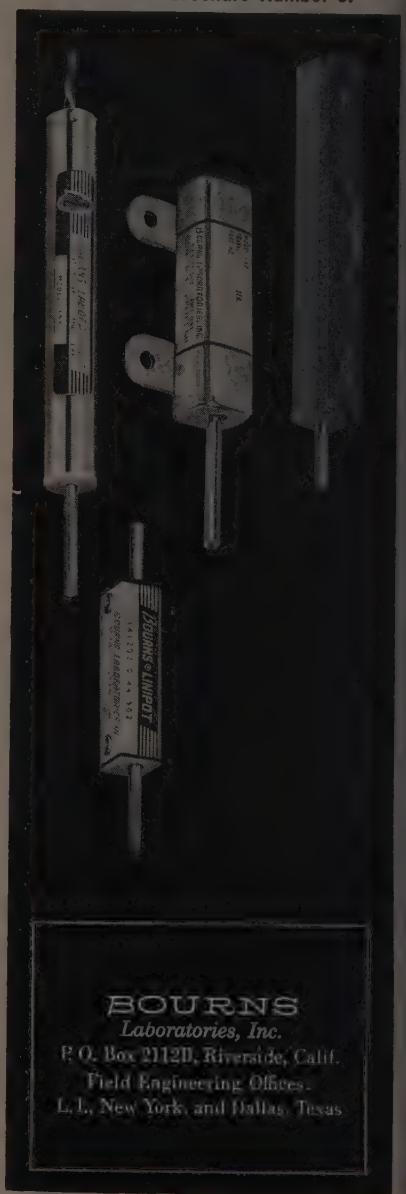
more on page 236

POSITION TRANSDUCERS by BOURNS

The complete line of Bourns transducers is a result of over ten years engineering and manufacturing experience. Available in travels of ½" to 32", Bourns transducers are designed to give reliable service under extreme environmental conditions. Get time-proved dependability —specify Bourns in your instrumentation and test programs.

Write for new Instrument Brochure Number 3.



PIONEERS IN POTENTIOMETER TRANSDUCERS FOR POSITION, PRESSURE, AND ACCELERATION. EXCLUSIVE MANUFACTURERS OF TRIMPOT®, TRIMIT®

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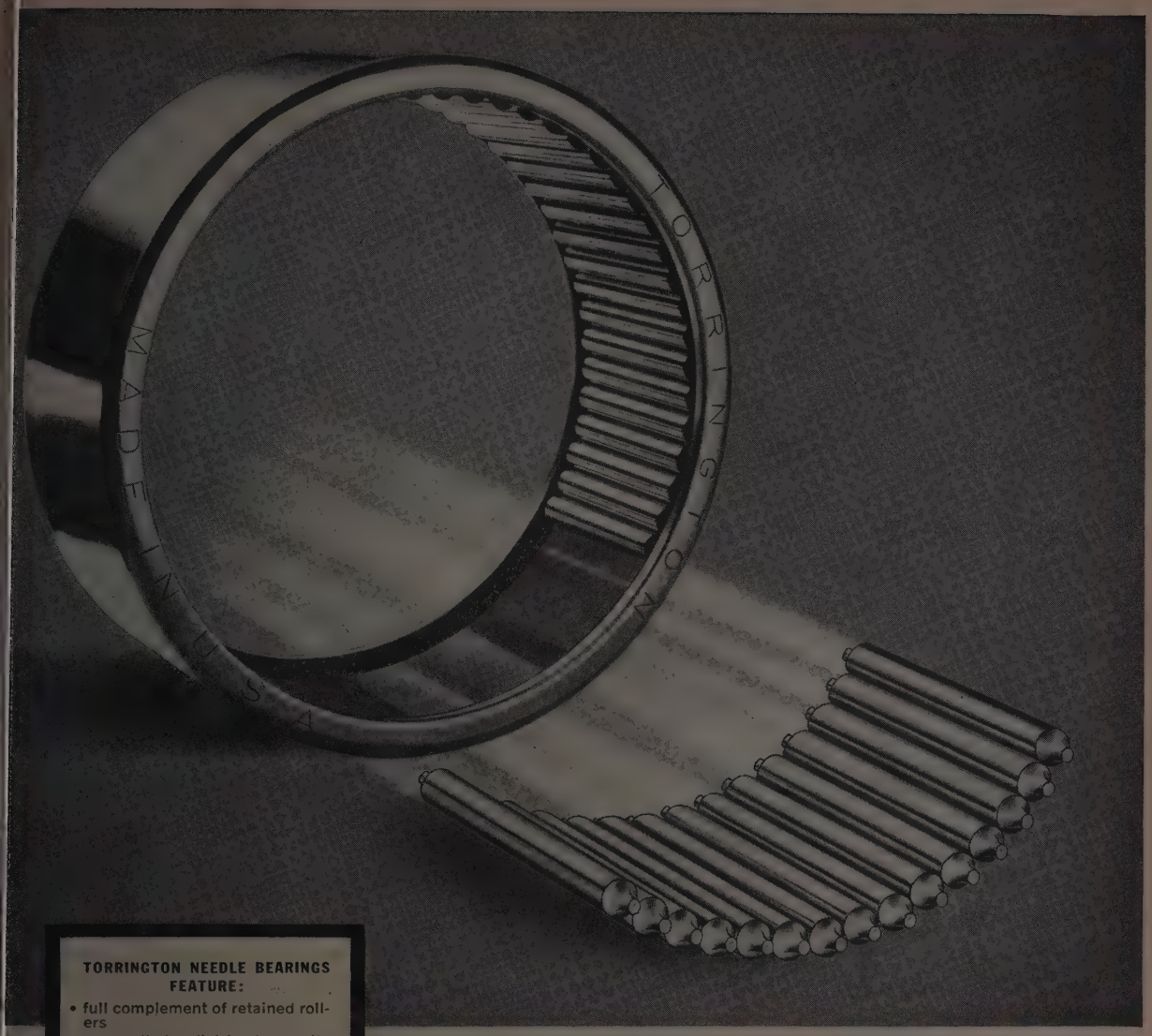
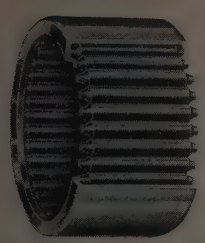


TORRINGTON NEEDLE BEARINGS FEATURE:

- full complement of retained rollers
- unequalled radial load capacity
- low coefficient of starting and running friction
- low unit cost
- long service life
- compactness and light weight
- runs directly on hardened shafts
- permits use of larger and stiffer shafts



Here's Why Torrington Needle Bearings Provide Maximum Radial Load Capacity

The Torrington Needle Bearing's full complement of small diameter rollers provides the largest possible number of bearing contact lines in the load zone.

This feature gives Needle Bearings a higher radial load capacity than any other bearing of comparable size. Precision rollers ensure smooth anti-friction performance with low coefficient of starting and running friction, to match this unequalled capacity. Rollers are positively retained by the turned-in lips of the outer shell, permitting simple, economical installation and assembly.

Torrington experience spans twenty years in design and application of Needle Bearings to equipment of all types. This experience is at your disposal to help you secure the ultimate in performance built into every Torrington Needle Bearing. **The Torrington Company, Torrington, Conn.—and South Bend 21, Ind.**

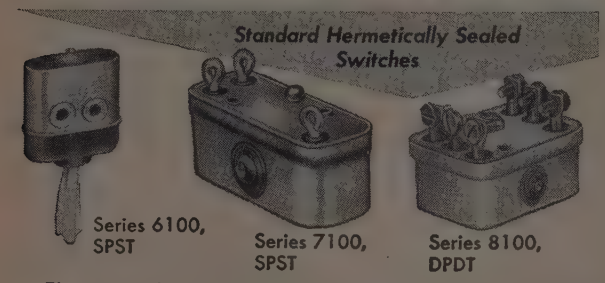
TORRINGTON BEARINGS

District Offices and Distributors in Principal Cities of United States and Canada

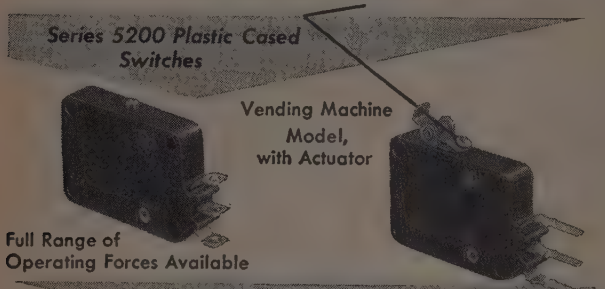
NEEDLE • SPHERICAL ROLLER • TAPERED ROLLER • CYLINDRICAL ROLLER • BALL • NEEDLE ROLLERS • THRUST

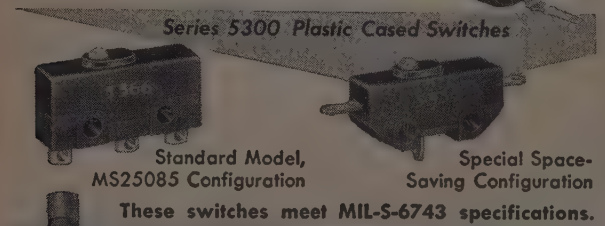
Write in No. 102 on Reader Service Card at start of Product Preview Section

HAYDON . . . RELIABLE SOURCE FOR MINIATURE SNAP-ACTION SWITCHES

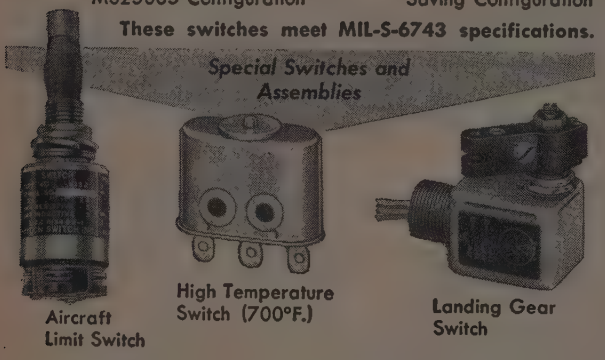


These switches meet requirements of MIL-S-6743 and MIL-E- 5272A, Procedure II (vibration).





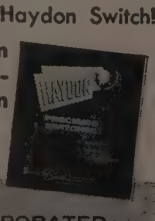
These switches meet MIL-S-6743 specifications.



These are only a few of the many precision switches developed by Haydon for aircraft and industrial applications. Haydon engineers are prepared to solve *your* switch design problems—or call on one of their twenty-three field offices for immediate help.

For accurate, dependable performance in miniature and subminiature switches, it pays to contact Haydon Switch!

As a starter, send for the new Haydon Catalog containing full data and specifications on standard and special precision switches.



HAYDON Switch INCORPORATED
WATERBURY 20, CONNECTICUT

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HIGH TEMPERATURE PUMP for testing

The Kobe Triplex pump is an exceptionally heavy duty pump which meets the rigid requirements of high temperature, high pressure testing of hydraulic components and systems used in aircraft. It operates at temperatures in excess of 500 deg F at pressures up to 5000 psi, says **Kobe, Inc., Dept. S/A, 3036 E. Slavson Ave., Huntington Park, Calif.**

It has closely fitted metal-to-metal plungers and liners which eliminate the need for seals. The forged steel fluid head is separated from the crankcase by a one-piece steel spacer block so that crankcase temperatures will not exceed 180 deg F. The pump is available either with stub shaft or integral electric motor.

Write in No. 201 on Reader Service Card

DIGITAL INDICATOR for transducer output

The Model 600 digital indicator is designed to display the output of differential transformer transducers on an electronic decade counter. It is normally furnished with a range or span adjustment for transducer core motions in ranges from 0-.010 to 0-.050 in, according to **Daytronic Corp., Dept. S/A, 216 S. Main St., Dayton 2, O.**

The unit incorporates a rotary potentiometer, connected in a bridge circuit with the transducer, that is driven continuously by a synchronous motor at a speed in synchronism with the transducer carrier frequency. Output of the device is expressed in per cent of transducer range. An automatic three-sec cycle uses one sec to get a reading and the remaining time to display it. The reading cycle can also be initiated by an external command or by a panel button.

Write in No. 202 on Reader Service Card

TRANSISTORS in twelve types

Twelve new PNP Germanium Transistors in the JETEC-30 standardized package is announced. Type 2N425, 2N426, 2N427, and 2N428 are especially for computer use and have alpha frequency cutoff values of four, six, 11 and 17 megacycles respectively. Types 2N416 and 2N417 are for special purpose RF use and cutoff values of ten and 20 megacycles respectively, says **Raytheon Mfg. Co., Dept. S/A, 55 Chapel St., Newton 58, Mass.**

For portable radio receiver circuits there are six new types. 2N413 is designed for local occillator use. Types 2N414 and 2N415 are converters with 2N414 averaging 26 db and 2N415 averaging 30 db for conversion gain. Types 2N413 A, 2N414A and 2N415A are IF amplifiers with average power gains at 455 Kc of 32, 35, AMD 39 db respectively.

Write in No. 203 on Reader Service Card

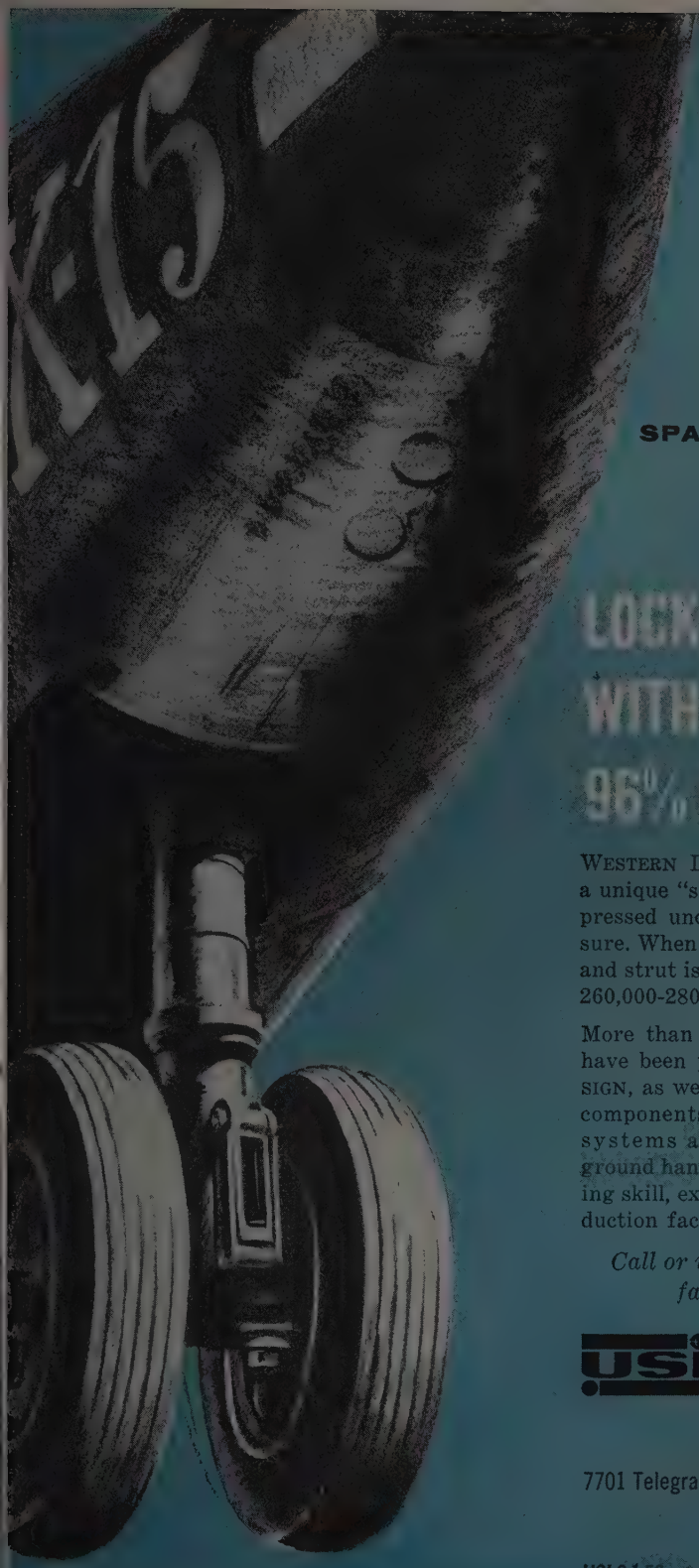
CR TUBE has big screen area

Type 3XP Cathode Ray Tube which increases the distortion-free useable screen area by 20 per cent, is available with P 1, P 2, P 5, P 7, and P 11 phosphors, says **Allen B. Du Mont Laboratories, Inc., Dept. S/A, 750 Bloomfield Ave, Clifton, N.J.**

The 3 in. screen flat-face rectangular tube reduces error from parallax and allows a more uniform light output. The tube also features a glass rodded gun construction which offers greater physical rigidity as well as improved electrical stability. The tube is designed to operate with accelerating voltages of 1000 to 2000 V d-c. Deflection factors in the y-direction with 1000 V are 12.5 to 17.5 d-c to move one inch with 2000 volts accelerating voltage. The 3 in. by 1½ in. rectangular screen tube is 8¾ in. long and has electronic deflection and focus.

Write in No. 204 on Reader Service Card

more on page 240

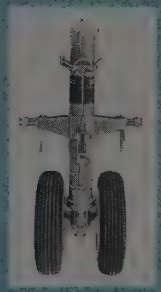


SPACE SAVING DESIGN

LOCK HOLDS 27,750 LBS. WITH GEAR COMPRESSED 96% OF STROKE

WESTERN DESIGN developed the X-15 nose gear with a unique "shrink lock" that holds the strut safely compressed under 2.6 times the normal compressed pressure. When gear is dropped, lock automatically releases and strut is fully extended. Steel parts are heat treated 260,000-280,000 psi tensile strength.

More than 50,000 landing gear units have been produced by WESTERN DESIGN, as well as other proven airborne components, assemblies, accessories, systems and ground support and ground handling equipment. Engineering skill, experience and extensive production facilities are available to you.



Call or write today for 28-page facilities brochure.

USI **Western Design**

DIVISION OF U.S. INDUSTRIES, INC.

Santa Barbara and Montebello, California

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USI-2-1-59

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Marquardt

ADVANCED TEST FACILITIES

FOR AIR AND SPACE

1

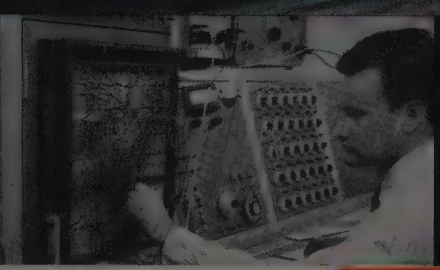
2

Test facilities conceived, designed, developed, and operated by Marquardt Aircraft—which include the USAF-Marquardt Jet Laboratory and test installations of the U. S. Navy—perform an important role in the development of advanced propulsion systems, controls and accessories for air and space operations. Here, in a creative engineering environment, professional engineers specializing in analysis, design, and operation of test equipment are constantly challenged by the complex requirements which must be satisfied to support critical development programs, including test support for long-range space research projects currently underway. Simulation of high altitude engine and equipment operating conditions, handling and testing with new chemical fuels, solving the problems of extreme temperatures and vibration, extrapolation of data for space applications, and recording test data under conditions never before simulated, are only a few of the research and development areas presently being explored by engineers in Marquardt's Test Division.

Engineers and scientists whose training and experience qualify them for responsible positions in the analysis, design, and operation of such advanced facilities will find full opportunity to demonstrate their talents at Marquardt. May I suggest you contact Mr. Floyd E. Hargiss, Manager of the Professional Personnel Department, 16547 Saticoy Street, Van Nuys, California.

Roy E. Marquardt, *President*

Check Employment Inquiry Form on Page 181



1—**Test Division** engineers under Chief Engineer Leigh Dunn (center) pioneer advanced development programs in Marquardt's unique and modern test facilities. Professional engineers wishing to join this creative engineering environment will find opportunities in many fields, including:

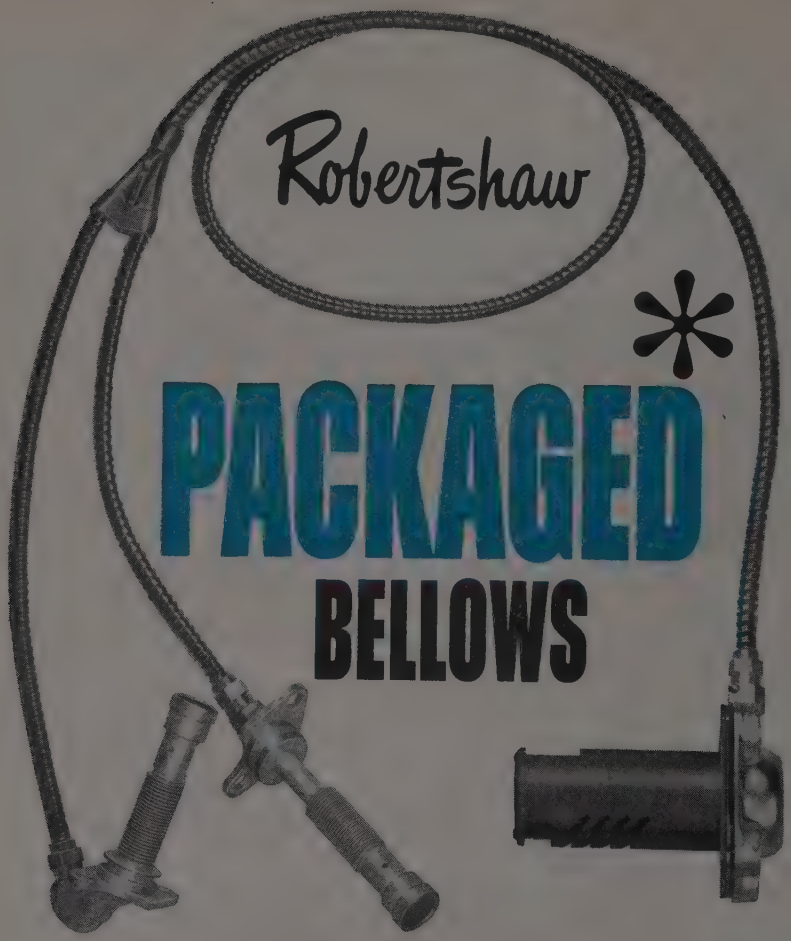
2—**Facility Design**—Engineers experienced in design, mechanical and thermodynamic analysis of industrial processes including systems for large air flow, steam, fuels, propellants, and oxidizers for both cryogenic and extreme temperatures.

3—**Instrumentation**—Engineers to advance the design of high-speed recording systems and analog computers and to use these systems in the collection of test data.

4—**Facility Operations**—Engineers to coordinate and supervise the setup and operation of test programs for supersonic jet engines, engine controls, and rotating accessories.

Marquardt
AIRCRAFT CO.

VAN NUYS AND POMONA, CALIFORNIA—OGDEN, UTAH



...why you save on custom-engineered "one-source" bellows and accessories

* It pays to specify seamless metal bellows *and all assembly components* as one "package"—designed as an integral unit . . . produced to one high standard of quality . . . tested under uniform procedures . . . and delivered already assembled.

Custom-engineered Robertshaw Packaged Bellows save handling, assembling, testing, incoming inspections and paper work in your plant. And you benefit from one source responsibility, no scattered deliveries and lowest possible unit costs.

Wide selection of bellows metals permits outstanding uniformity and stability under tough conditions of temperature, pressure, corrosion and vibration. Bellows sizes from subminiature ¼" O.D. up to several inches O.D.

Discuss your Packaged Bellows needs with a Robertshaw engineer . . . or get started right now by writing for Bellows Bulletin G-104.

Mr Controls

Robertshaw-Fulton CONTROLS COMPANY

BRIDGEPORT THERMOSTAT DIVISION • Milford, Conn.

Write in No. 105 on Reader Service Card at start of Product Preview Section

TEMPERATURE METER is transistorized

A new, transistorized, high-sensitivity version of their miniature temperature-measurement subsystems for missile and aircraft flight testing is announced by **Arnoux Corp., Dept. S/A, Los Angeles, Calif.** The TME-ISD and TME-28D are for use with fast response, 100-ohm-resistance temperature transducers to produce a full five-volt output for a span of only 75 F. They are single and double channel units, respectively.

Ecept for transducers, the units are self-contained. They meet MIL-E-5272A environmentally.

Write in No. 239 on Reader Service Card

PHASE SHIFT CIRCULATOR for C-Band

Model W269-2A-1 C-band ferrite differential phase shift circulator operates over the common carrier and mobile bands between 5.975 and 6.425 kmc, says **Kearfott Company, Inc., Microwave Div., Dept. S/A, 14844 Oxnard St., Van Nuys, Calif.**

Isolation is better than 20 db between any input terminals and arbitrary output terminals, while insertion loss is less than 0.07 db over the entire range. VSWR is less than 1.25 at any input terminal over the band. Unit handles 20 W of average power and a peak power of one KW. Operating temperature range is −30 to +125 deg C.

Write in No. 240 on Reader Service Card

CONTROL SYSTEM for fluid level

Both ground and inflight applications are provided by an automatic fluid level control system available from **Koehler Aircraft Products Co., Dept. S/A, 409 Leo St., Dayton 4, O.** In ground fueling, it can minimize fuel time and insure an accurate fill with maximum safety; for inflight use, the system automatically maintains CG by transferring fuel between tanks.

The systems, each of which contains a pilot and shut-off valve as integral or separate installations, can be used with cryogenics and oxidizers, as well as with high-energy and standard-type fuels.

Write in No. 241 on Reader Service Card

more on page 242

NEW VOUGHT CRUSADER FOR FLEET NEXT YEAR!

Navy orders fourth version of flexible, economical fighter

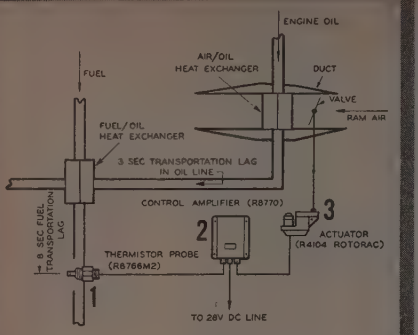
For the fourth time in three years, a new *Crusader* type is extending the power of the Fleet. Chance Vought's F8U-2N has been ordered by the Navy for delivery next year. It will deploy alongside the Navy's swiftest photoplanes and two first line day fighters – all *Crusaders*.

The F8U-2N is another step in *Crusader* growth. Speed of this newest version has been advanced to near Mach 2. It will carry the deadliest air-to-air missiles. It is instrumented and radar-equipped for supersonic combat in darkness or bad weather.

This will be a new capability for the Fleet. Yet it is being acquired at low risk and cost. The F8U-2N's basic design has been proved simple, serviceable and economical . . . compiling an enviable performance record in a year of foreign duty with two Fleets.

Again, the growth provisions of the Vought *Crusader* have provided immediate, low-cost upgrading of the Fleet's aircraft inventory.

CHANCE VOUGHT AIRCRAFT
INCORPORATED · DALLAS, TEXAS



AIRBORNE R8010 TEMP. CONTROL SYSTEM

Schematic diagram of temperature control system developed by Airborne for use on Martin P6M-2 Seamaster. System operates on 28 v d-c, maintains fuel temperature at approximately 200°F. by monitoring ram air flow to air/engine oil heat exchanger. Oil is used in turn to heat fuel.

Airborne electromechanical system regulates jet fuel temperature

Besides offering an extensive line of linear and rotary actuators, Airborne can also meet your requirements for complete electromechanical control systems. An example is the R8010 Temperature Control System designed and developed for Martin and illustrated here. Four of these systems are used on the P6M-2 Seamaster to maintain fuel temperature at 180-220°F. If you have a similar requirement—for an aircraft, missile or ground application—why not contact Airborne. Our capabilities in special actuators, motors and related equipment make it likely that we can meet your needs exactly. Write or phone for further information.

AIRBORNE R8010
Temperature Control System
General Engineering Data

1. Probe: Sensitive thermistor type mounted in MS10057-12 fitting. Resistance—nominally 10,000 ohms at 200°F.—varies with temperature.

2. Control Amplifier: Transistor-relay type. Service temperature range from –65 to +200°F. Vibration and shock per MIL-E-5400A. Acceleration to MIL-E-5272A.

3. Actuator: Partial-revolution, conforming to MIL-A-8064A. Motor—26 v d-c, reversible, continuous duty, conforming to MIL-M-8609. Actuator speed—.12 rpm at normal torque of 84 in./lb. Design incorporates electric clutch, limit switches, positive mechanical stops, radio noise filter.

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Engineered Equipment for Aircraft and Industry

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CONVERTERS are rugged

Ac-to-dc static converters that are able to withstand the extreme operating conditions encountered in aircraft and missiles have the merits of small size and light weight, says **R/S Electronics Corp., Dept. S/A, 435 Portage Ave., Palo Alto, Calif.** The Model 2596-A, which delivers 25 amps of load current at 28 V dc, is 5¾x4¼x4 in., and it weighs 7.20 lbs.

Maximum voltage excursion under all adverse conditions is 26 to 30 V dc. The unit operates from –55 to +85 deg C. Other models are rated for output power up to 5.5 kw.

Write in No. 205 on Reader Service Card

TELEMETRY DATA SYSTEM is automatic

The Mark 1 is a basic automatic PDM-to-digital computer-format telemetry data system. The system operates without calibrations or adjustments and performs with an overall accuracy of better than ±0.1 per cent, says **Epsco, Inc., Dept. S/A, 588 Commonwealth Ave., Boston, Mass.**

The complete system includes manual zero and 100 per cent data correction as well as arbitrary selection of data records and mode of operation associated with the PDM frame rate.

Write in No. 206 on Reader Service Card

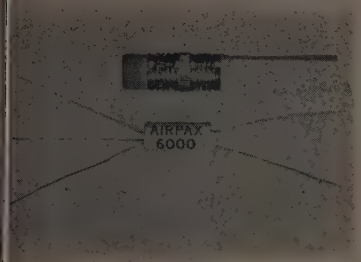
TINY RELAY is ruggedly built

A relay weighing under .5 oz and less than one in. long that withstands extremes of vibration, shock and temperature has been designed for control systems, computers, aircraft, and missiles. It has a life expectancy of 100,000 operations, minimum, at rated load, says **Comar Electric Co., Dept. S/A, 3349 W. Addison St., Chicago 18, Ill.**

The Type S-M relay can be used continuously at temperatures between –65 to +125 deg C. It is a dpdt unit with a maximum operate time of one msec, maximum release time of three msec, and maximum contact bounce of one msec. Nominal coil voltage is 26.5 V dc and contact rating is two amps at 28 V dc, resistive.

Write in No. 207 on Reader Service Card

TRANSISTOR CHOPPER *is miniature*



This transistor chopper switches signal source to load at frequencies from 0 to 100 Kc. Having no moving parts, the unit can operate under extremes of shock and vibration, says the **Airpax Product Co., Cambridge Division, Dept. S/A, Jacktown Rd., Cambridge, Md.**

The transistor chopper may be driven by a sine or square wave with a peak-to-peak amplitude of from 1 to 18 Volts. The sine wave peak-to-peak drive voltage should exceed the maximum signal voltage by a factor of 8 for good linearity; this factor reduces to three for square wave drive. Where 15 per cent linearity is sufficient, the sine wave factor reduces to 3 and the square wave to 2. Two types are available. Type 6000 operates at temperature ranges from —40 C to +60 deg C and can accommodate an input signal from a fraction of a millivolt up to 5 volts. Type 6010 operates at temperature ranges from —40 to +85 deg C and extends the upper signal level to 10 Volts.

Write in No. 208 on Reader Service Card

INDICATOR TUBE *for long range viewing*

This three-inch-diameter, all-electronic line inductor meets the need of visual presentation at distances of over 150 feet, says **Burroughs Corp., Dept. S/A, Plainfield, N.J.** Called the Jumbo Nixie Type BD-307, this device contains the numerals 0 through 9 and a common anode. The desired numeral is illuminated with a neon glow by applying a voltage between it and the common anode.

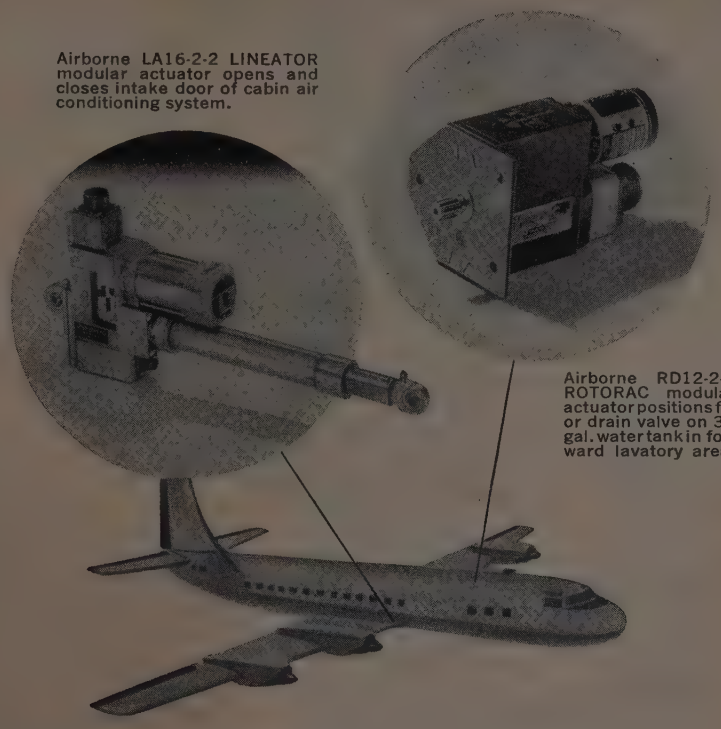
Low power, rugged construction, brightness and clarity are additional features.

Write in No. 209 on Reader Service Card

more on next page

AIRBORNE MODULAR DESIGN ACTUATORS SPECIFIED FOR ELECTRA CABIN SYSTEMS

Airborne LA16-2-2 LINEATOR modular actuator opens and closes intake door of cabin air conditioning system.



Airborne RD12-2-3 ROTORAC modular actuator positions fill or drain valve on 30 gal. water tank in forward lavatory area.

With Airborne modular actuators, you are no longer limited to a few standard models whose design is relatively fixed. Instead you can specify any one of several hundred possible combinations of interchangeable parts to get exactly the capacity and configuration you want. This gives you greater design freedom without the cost and delay of specials.

While redesigning under the modular concept, we have also reduced the size and increased the performance of many Airborne actuator components. You get more power in a smaller package, save valuable weight and space.

For full information on Airborne modular design electromechanical actuators, request Bulletin 57A (linear type) or Bulletin MR-58 (rotary).

GENERAL ENGINEERING DATA

Airborne Modular Design LINEATOR Actuator LA16-2-2

1. 115 v a-c, 400 cycle reversible motor with magnetic brake
2. Speed at normal load of 400 lb.: .2 in./sec. (max. op. load—1690 lb.; max. static load—3230 lb.). All noted loads in tension
3. Ambient temperature: —65 to +160°F. Altitude to 55,000 ft.
4. Weight: 4.4 lb.
5. Design incorporates 2 limit switches, 2 intermediate position switches, nonjamming positive stops, overload slip clutch, synchro transmitter.

Airborne Modular Design ROTORAC Actuator RD12-2-3

1. 26 v d-c, split field, series wound reversible motor with magnetic brake—capable of continuous stall
2. Speed at 20 in./lb. normal torque: 1.7 rpm
3. Weight: 1.1 lb.
4. Design incorporates 2 limit switches, 2 intermediate position switches, nonjamming positive stops, overload slip clutch.

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REPUBLIC VALVES
FOR EVERY INDUSTRY

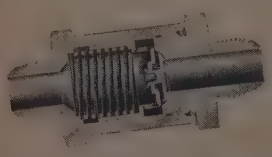
CHECKS

THAT FILL YOUR NEEDS

MINIATURE CHECKS

Mini-Valve Regular Size Valve

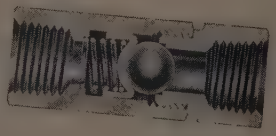
Save weight and space with Mini-Valves. They have same rated flow as regular size, but are only ¼ the size and weight. Good pressure drop characteristics. Temp. range −65° to plus 400°F. Operating pressure to 5000 psi. One-piece stainless steel body, in tube sizes 4 to 16 (¼" to 1" O.D.) Meets or exceeds requirements of MS MIL-V-25675. Port threading MS33514 flareless.



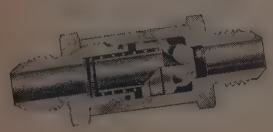
FREE-FLOW CHECKS

Extremely low pressure drop, with wide open flow. Molded elastomer seal and spherical seat prevent leakage at any pressure. Sizes ⅛" to 2" in brass and aluminum alloy up to 3000 psi, and stainless steel to 4000 psi. Opens at 2 psi. Temp. range −65° to 200°F. Pipe, internal straight thread and flared tube connections standard; MS33514 flareless available.

BALL CHECKS



Ruggedly constructed for intermittent non-shock hydraulic service up to 500 psi at temperatures −65° to 350°F. Sizes ⅛" to ¾". Brass, aluminum alloy, stainless steel. Pipe and flared tube connections.

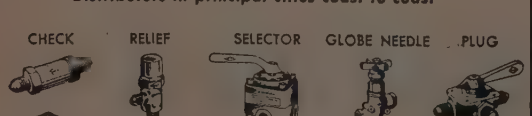


HY-PRESSURE CHECKS

Built for continuous service in high velocity systems at pressures up to 5000 psi in steel and stainless steel, and 3000 psi in aluminum alloy. Low pressure drop. Metal-to-metal seal. Operating temperatures −65° to 250°F. Sizes ⅛" to 2", with pipe, internal straight thread and flared tube connections. MS33514 flareless available.

Distributors in principal cities coast to coast

CHECK RELIEF SELECTOR GLOBE NEEDLE PLUG



RM REPUBLIC MANUFACTURING CO.

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PRESSURE WINDOW for half-X waveguide use

A new flange-mounted wave-guide pressure window, MA-1339, for use in half-X waveguide applications covers the frequency range from 9.5 to 10.1 kmc with a maximum VSWR OF 1.1 at the band edges. Resonant frequency is 9800 mc. It is used in 0.2x0.9 ID waveguides, says **Microwave Associates, Inc., Dept. S/A, Burlington, Mass.**

Window flange thickness is 0.06 in. Maximum power rating is 20 kw. Maximum pressure handling capability is 45 lb on the glassed side of the window. The windows are constructed of kovar and glass. All metal surfaces are silverplated.

Write in No. 210 on Reader Service Card

VIDICON TUBE is slow-scanning

Type WL-7290, a small size vidicon camera tube, is designed for slow speed scanning operation. The low residual current of this tube permits high resolution, long-storage time with higher sensitivity, higher output signal and better signal-to-noise ratio, says **Westinghouse Electric Corp., Electronic Tube Div., Dept. S/A, P. O. Box 284, Elmira, N.Y.**

The tube can store images for several minutes without loss of detail. A high-quality picture, 350 line resolution, can be held for two minutes.

Write in No. 211 on Reader Service Card

SERVO MOTOR for high temperatures

A two-phase servo motor for use in 600-deg F ambient air has been developed by **Thompson Products, Inc., Dept. S/A, 2196 Clarkwood Rd., Cleveland, Ohio.** The control phase input of Model 07-0001 is zero to 115 V, 400 cps, and the fixed phase input is 115 V, 400 cps.

Acceleration at stall is 5380 rad/sec^2 at 75 deg F and 4500 rad/sec^2 at 600 deg F. The 2½-lb, 2,675-in at 30 rpm, at 550 deg F and a long unit has a torque of 150 in-oz.

Write in No. 212 on Reader Service Card

PUSHBUTTON SWITCH is oiltight

Type 16 subminiature switch with double break contacts, is rated at 10 amps, 125, 250 V ac or 30 V dc, says **Licon Div., Illinois Tool Makers, Dept. S/A, 6606 W. Dakin St. Chicago 34, Ill.** Button mechanism is sealed with oil and coolant resistant neophrene. Integral O-ring seals bushing to panel. Switch is quickly clipped to panel-mounted button after wiring.

Several styles are available in single pole through four pole assemblies for multiple circuitry.

Write in No. 213 on Reader Service Card

FERRITE ISOLATOR for 2350 to 3600 mc

This special broad band resonant absorption ferrite isolator is for use in microwave systems operating over the broad frequency band of 2350 to 3600 mc/s. The ferrite isolator is constructed in special double ridge waveguide to obtain the extremely broad band frequency performance and is supplied with R-284 (3.00 x 1.50) transitions to permit its use with standard S-band systems, says **Airtron, Inc., Dept. S/A, 1101 Elizabeth Ave., Linden, N.J.**

Electrical characteristics include a minimum isolation of ten db, input VSWR of 1.20, maximum power handling capacity averaging 400 W C.W. and a maximum insertion loss of 0.5 db in S-band systems and 1.0 db in coaxial systems.

Write in No. 214 on Reader Service Card

more on page 246

FOR AMERICA'S DEFENSE

STEWART & STEVENSON LEADS THE WAY IN ENGINE ELECTRIC GROUND SUPPORT UNITS

For missile launching sites, radar and dozens of other locations requiring precise electric power in our Nation's defense program, Stewart & Stevenson dependable engine electric generator sets are on the job.

For the right answers to any power problem—for any industry—look to Stewart & Stevenson.

THE WORLD'S LARGEST DISTRIBUTOR OF DIESEL ENGINES

STEWART & STEVENSON SERVICES, INC.

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Main Office:	Houston 11, Texas
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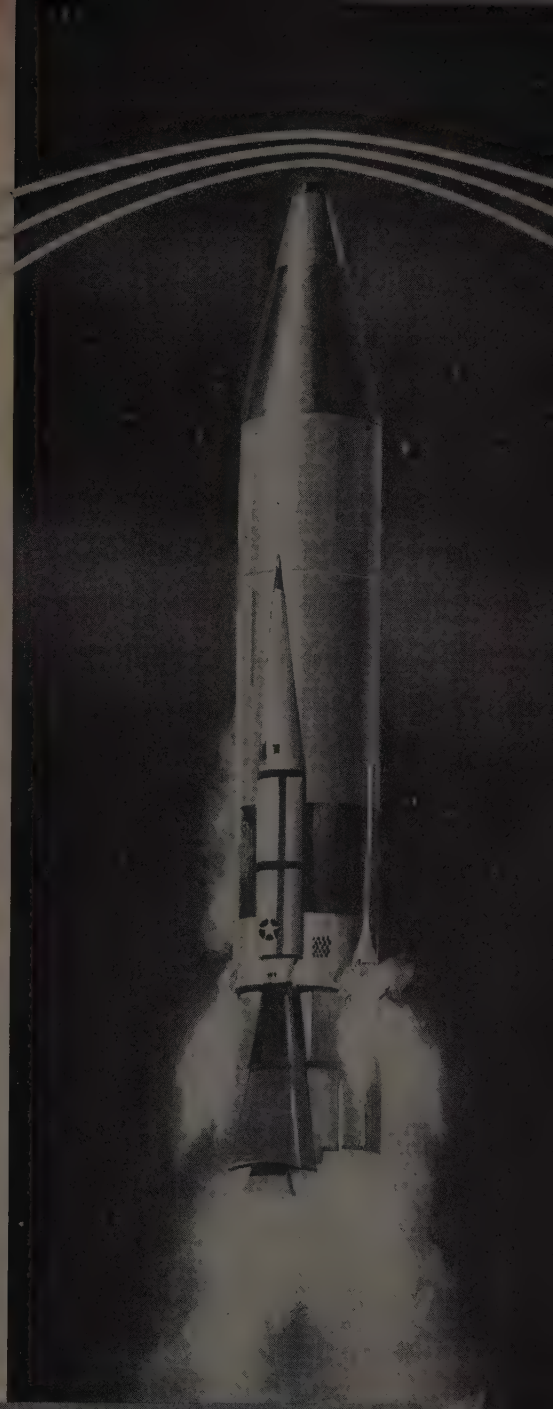
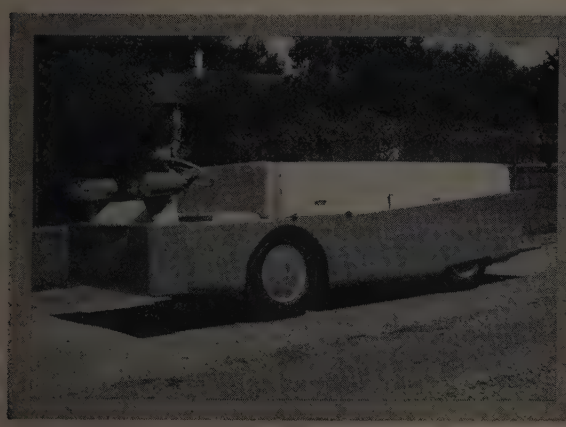
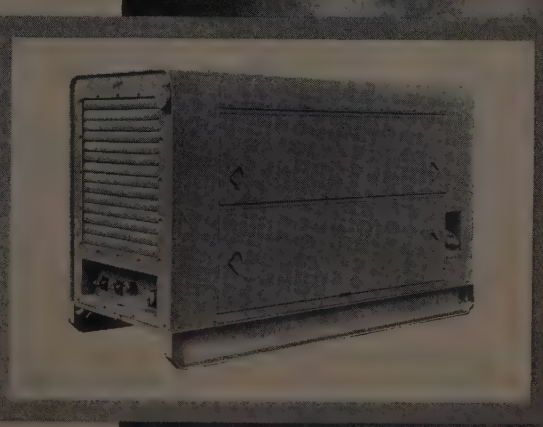
Representatives:	Longview, Brownsville, Wichita Falls, Freeport.
Export:	Room 1405, 74 Trinity Place, New York, N. Y. Houston 11, Texas, 4516 Harrisburg Blvd.,







For Safe Flexible Fluid Handling Lines— specify CHIKSAN SWIVEL JOINTS

FOR MISSILE FUELING

Swivel Joints and assemblies to handle cryogenic liquids and fuels in ground loading and topping hose. Assemblies developed to handle services ranging from −320°F to +600°F and pressures from 20″ vacuum to 15,000 psi.

FOR GROUND SUPPORT EQUIPMENT

Loading arms and flexible transfer assemblies for handling Lox, N_2, He, JP Fuels, H_2O_2 and Hot Gases. Sizes range from ¼″ to 16″. Corrosion resistant steel, nickel, brass, aluminum, bronze and other metals available.

FOR GROUND HANDLING EQUIPMENT

Swivel Joints and assemblies to handle hydraulic, pneumatic, and fuel systems on launching vehicles and missile transporters. Units for rotation in 1, 2 or 3 planes in widest variety of metals, pressure and temperature available.

FOR AIRCRAFT SYSTEMS

Compact, lightweight package units in ¼″, ⅜″, ½″ and ⅝″ O.D. tubing sizes. Pressures of 28″ vacuum to 4,000 psig. Temperatures of −65°F to +275°F. AN and MS standard end connections.

CHIKSAN COMPANY

A SUBSIDIARY OF FOOD MACHINERY AND CHEMICAL CORPORATION
CHIKSAN COMPANY — BREA, CALIFORNIA

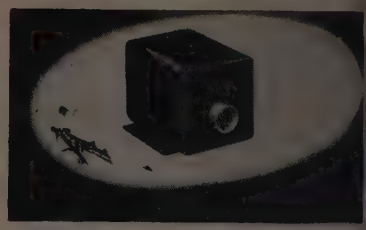
Send for informative Bulletin 558

59-41

Write in No. 110 on Reader Service Card at start of Product Preview Section

PRODUCT PREVIEW

MONITOR has multiple channels



Designed to accommodate either ac or dc signals, this signal comparator compares the level of the monitored signal with a reference voltage and actuates a relay so that contact position depends upon the monitored signal, says **Avien Inc., Dept. S/A, 58-15 Northern Blvd., Woodside 77, N. Y.**

The unit can be used in either airborne or ground checkout applications and in other systems in which equipment readiness is indicated by a specified level of signal voltage. The device can be supplied in single-, dual-, or multi-channel arrangements. The input circuit can handle signals up to 10 V (the unit can also be supplied for higher levels). Operating power is 25 V dc and 115 V ac, 400 cps. Dimensions are $3\frac{3}{16} \times 3\frac{3}{16} \times 4\frac{9}{32}$ in. Weight is less than two pounds.

Write in No. 215 on Reader Service Card

more on page 248

Silicone Sponge Rubber

flexible at temperatures −100°F to 500°F

COHRlastic R-10470 has a dense, uniform, non-absorbing closed cell structure, highly suitable for soft gasketing, vibration dampening, fairing strips, pads, cushions and other applications where resiliency at extreme temperatures is required. It may be bonded to metals, plastics, fabrics or silicone rubber. Possesses superior compression set resistance, excellent dielectric properties, immunity to aging, ozone and weather hardening. Available from stock in 24″ x 24″ sheets −1/16″ through 1/2″. Special sizes and extruded shapes made to order.

FREE SAMPLES and folder — write, phone or use inquiry service.

CHR PRODUCTS: COHRlastic Aircraft Products — *seals, coated fabrics, and ducts;* COHRlastic Silicone Rubber Products — *moldings and extrusions, sheets and sponge;* Temp-R-Tape — *pressure sensitive, thermal curing Teflon and silicone tapes;* Allied Products — *COHRlastic silicone cements and conductive gasketing.*

CHR CONNECTICUT HARD RUBBER

Main Office: New Haven 9, Connecticut

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Three superlative Marsh products are widely used and approved by the aircraft and missile industry:

MARSH Pressure Gauges...

because they combine the most advanced features ever found in pressure, vacuum and compound gauges. There is a Marsh Gauge for every conceivable application.

MARSH Needle Throttling Valves...

because they are guaranteed to give micrometer regulation at HIGH pressures—pressure up to 10,000 psi—and any temperature up to 500° F.

MARSH Dial Thermometers...

because they offer the precision and accuracy a precision industry demands. Most complete line; wide temperature ranges, dial sizes, patterns, finishes.

All Marsh products available with AND threads

MARSH *New catalog covers all details*

MARSH INSTRUMENT CO. *Sales Affiliate of Jas. P. Marsh Corp.* **Dept. 43, Skokie, Ill.**

Marsh Instrument & Valve Co., (Canada) Ltd., 8407 103rd St., Edmonton, Alberta, Canada. Houston Branch Plant, 1121 Rothwell St., Sect. 15, Houston, Texas

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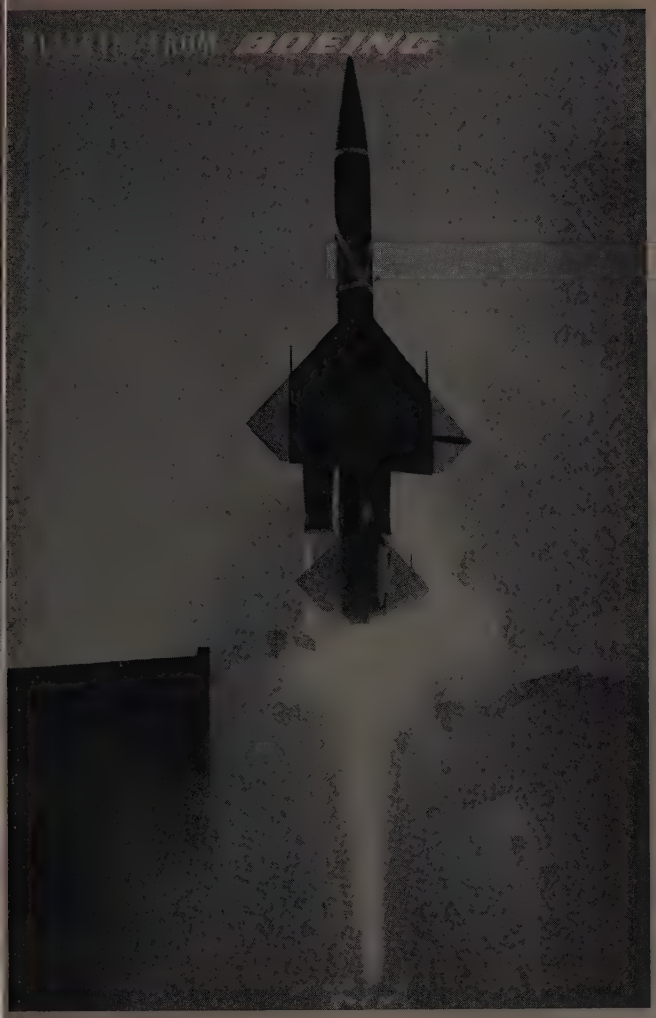
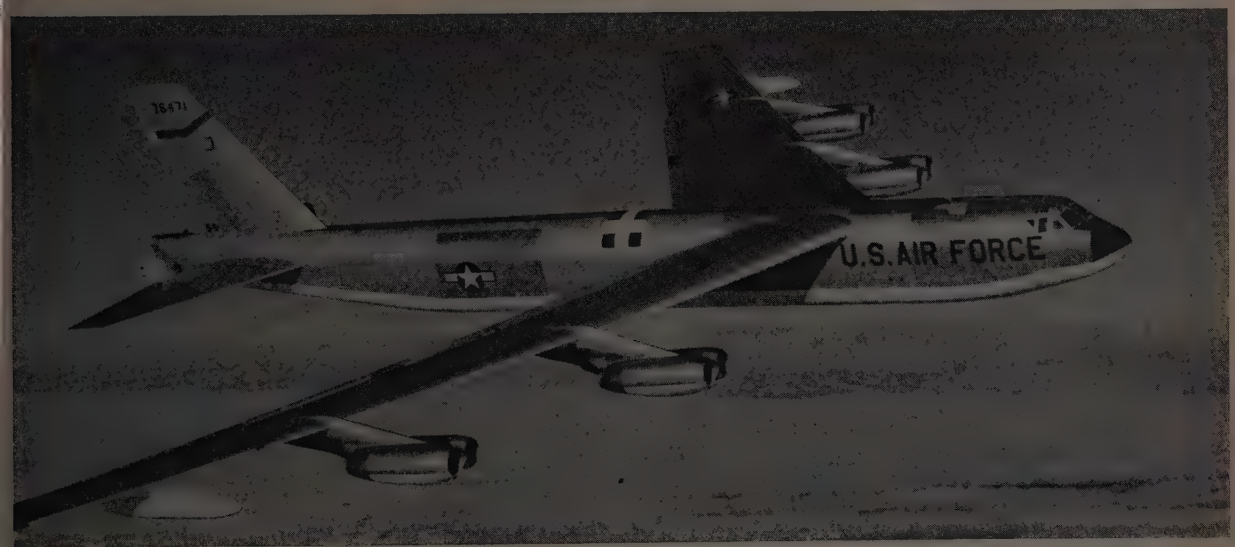


SUPERSONIC DEFENDER. Boeing BOMARC, the Air Force's longest-range defense missile, can seek out and intercept single or multiple targets long before they reach U.S. borders. One base, armed with a squadron of BOMARCS ready for instant action, can provide interceptor cover over thousands of square miles. Bases are now nearing completion. BOMARC can be developed to cope with intercontinental ballistic missiles.

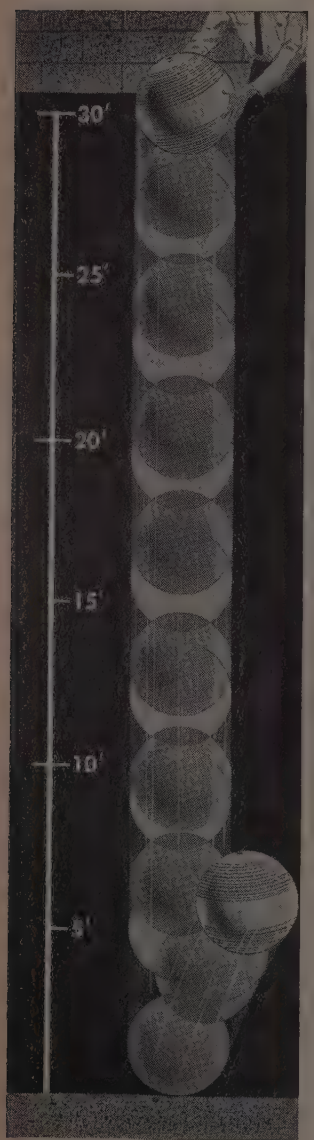
MAN IN SPACE. Space-age projects at Boeing include research to develop protective environments and efficient controls for crews of advanced aircraft and space vehicles. Boeing is also at work on orbital systems, a boost-glide vehicle, and Minuteman, a solid-propellant intercontinental ballistic missile under development.



MISSILE BOMBER. Boeing B-52G, now in operation with the Strategic Air Command, is world's longest-range jet, and U.S. Air Force's most versatile long-range weapon system. B-52G carries supersonic air-to-ground missiles for in-flight launching hundreds of miles from target areas, in addition to regular nuclear bomb load. B-52G can strike several targets thousands of miles apart on a single retaliatory defense mission.

BOEING

GAS OR LIQUID—STORED SAFELY IN LIGHT, SHATTERPROOF BOTTLES



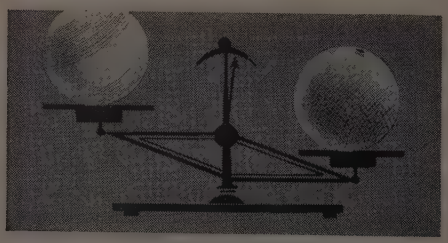
SHATTERPROOF—*Charged to 3,000 PSI, these Bendix bottles withstand a 30-foot drop to a concrete floor without damage. Absolutely no flying particles to damage personnel or equipment! Tests show even 50-caliber bullets can no more than rupture the material.*

Exceptionally light as well as safe, Bendix fibre glass bottles qualified for government and industrial applications are in mass production.

Developed originally as a high-pressure air reservoir for jet aircraft, this new type lightweight container offers exciting possibilities if you have a problem in storage of either high-pressure gas or liquid.

PROVED SUPERIORITY

Proved superior in pressurized operation on missiles and turbine-engine aircraft, Bendix light, shatterproof storage bottles by Apex are made from continuous windings of fibre glass yarn impregnated with epoxy resin. The bottles are wound on a precision machine designed to place yarn so it utilizes the greatest strength. The result is safe, non-corrosive bottles—with a temperature range from minus 65°F. to plus 200°F. and a built-in thermo-lag.



UP TO 40% SAVINGS IN WEIGHT *over steel containers for same volume and pressure.*

Operating pressures of present units vary from 3,000 to 4,500 PSI and burst pressures from 6,000 to 10,500 PSI; can be designed for other pressures as required. Most bottles are for 10,000-cycle life; bottles with shorter cycle life have been built. A variety of sizes is available.

Our Sales Engineering Department will welcome an opportunity to review your requirements for either spherical or cylindrical shaped containers and submit a proposal for your specific application.

West Coast: 117 E. Providencia, Burbank, Calif.
Canada: Aviation Electric, Ltd., 200 Laurentien Blvd., Montreal, Que.
Export Sales and Service:
Bendix International, 205 E. 42nd St., New York 17, N. Y.

Bendix Utica Division
UTICA, NEW YORK

Bendix AVIATION CORPORATION

Write in No. 114 on Reader Service Card at start of Product Preview Section

CONTROL AMPLIFIER is transistorized

This diminutive transistorized control amplifier is the heart of voltage regulation for the entire fire control system of a military aircraft; says **Packard Bell Electronics, Dept. S/A, 12333 W. Olympic Blvd., Los Angeles 64, Calif.**

The unit has an output impedance of less than three ohms, 0-50 kc; ripple, less than 50 mv peak-to-peak; regulation, ±1 per cent from 30 per cent to 100 per cent load (high current) ±1 per cent from no load to full load (low current); overall circuit gains is 60 to 80 db.

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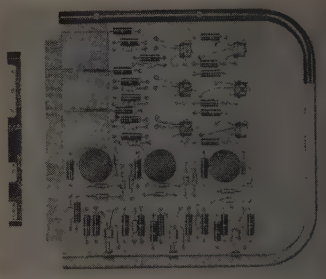
MEMORY SYSTEM uses magnetic core



The 3C memory incorporates transistorized plug-in packages, designed to handle core matrix driving and sensing circuits. Random access memories of up to 4096-word capacity and 40-bit word length are possible, says **Computer Control Co., Inc., Dept. S/A, 92 Broad St., Wellesley, Mass.**

Access time is four microseconds to any address; cycle time may be as short as eight microseconds. The basic unit consist of sense amplifier, current driver, inhibit driver, and selection switch. A typical 4096-word, 40-bit-per-word memory occupies less than six feet of panel space in a standard 19-in. relay rack.

Write in No. 217 on Reader Service Card

TORQUE MOTOR operates at 600 deg F

The Model 103-2 torque motor permits electrohydraulic or electropneumatic servovalves to be used in aircraft or missile systems without the need for complicated cooling systems or thermal lag provisions, says **American Measurement & Control, Inc., Dept. S/A, 240 Calvary St., Waltham 54, Mass.** The device can operate at 600 deg F temperatures, and it requires only four W of input power.

Midposition force is over eight lbs, and stroke is ±.008 in at a radius of .750 in. The motor measures 1⅛x $1\frac{11}{16}$x1¾ in. and weighs ten oz.

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more on page 252

Write in No. 115 Reader Service Card→

"ADVERTISEMENT"

The unseen enemy

How Summers Gyroscope guards against the invisible anti-missile

Vacuum equipment at each of the 240 individual assembly benches helps insure product reliability.

There is an invisible enemy operating in many plants producing the missile components, flight instruments, gyroscopes and other hyper-sensitive devices on which much of America's power for peace depends. The strength of this unseen foe is potentially as great as that of any anti-missile missile.

Destroyer Of Standards

This reliability destroying, efficiency reducing enemy is dust, lint and other foreign matter. The slightest air borne contaminant coming to rest unseen on sensitive mechanisms during assembly can cause serious, even fatal deviations in performance. Production was often slowed until tests showed the system to be free of dust.

Dust Moved But Not Removed

To combat the dust dilemma at the Summers Gyroscope Co. plant in Santa Monica, California, personnel donned lint free jackets and hats – walked to their work benches in shoe bags. Temperature and humidity were controlled in an attempt to achieve an environment completely free of every possible contaminant ranging from stray hairs to perspiration. However, these precautions proved only partially successful when it was found that a manual dust gathering system in the final assembly "clean room" actually recirculated dust instead of removing it.

Double Duty Production Tool

For a solution to the dust menace, Summers called upon U.S. Hoffman Machinery Corp., pioneers in the use of air as a production tool. Hoffman engineers installed a permanent stationary vacuum cleaning system which provided for necessary cleaning operations at all of the 240 individual work benches in the 12,000 square foot final assembly area. Standard attachments made this same system available for cleaning overhead and under foot, all over the plant.

Before And After

Prior to the installation of the Hoffman stationary system, relative cleanliness tests were conducted. A microscopic analysis of slides revealed lint, dust and other foreign matter in excess of quantities allowable to maintain Summers' high precision standards. A short time after the Hoffman equipment was placed in operation, the same tests showed a truly dust free "clean room".

How It Operates

Heart of the stationary cleaning system at the Summers plant is a 60 hp Hoffman centrifugal exhauster producing the vacuum. A centrally located dust separator outside the assembly rooms collects the material with large filtering area insuring thorough cleaning of the air. Hoses for cleaning are inserted into strategically located inlet valves in the piping system conveniently located throughout the areas to be vacuumed.

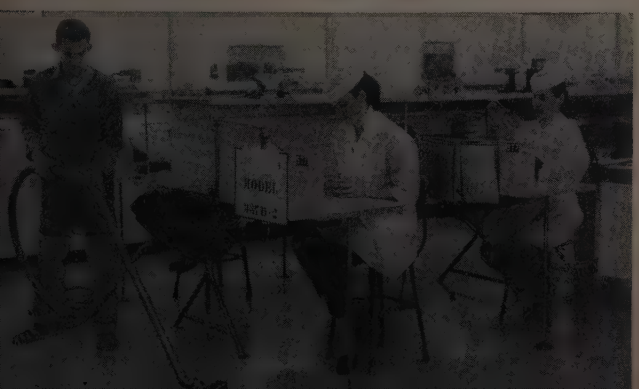
Benefits And Advantages

Insuring spotlessly clean work in final assembly and calibration, the Hoffman stationary vacuum system already has paid for itself. It has helped Summers Gyroscope reduce rejects, maintain high reliabilty, increase production and improve employee morale. The Hoffman system enables Summers to meet and exceed specifications in supplying inertial guidance systems, flight instruments and gyroscopes to the U. S. Air Force, U. S. Navy, the Martin Co., McDonnell Aircraft, Douglas Aircraft and the Convair Div. of General Dynamics, among others.

If you have a special cleaning problem in your plant, ask for a free engineering survey to determine the most economical Hoffman system to prevent product contamination, salvage valuable materials, insure better housekeeping and encourage operating efficiency. Write for free booklet – How Stationary Vacuum Cleaning Systems Cut Costs, Increase Plant Efficiency.

U.S. Hoffman Machinery Corp.
Dept. S-1 Air Appliance Division
103 Fourth Ave., New York 3, N. Y.

Note how the Hoffman vacuum system handles both parts cleaning, (rear) and housekeeping chores.



A final assembly area is kept dust-free by the Hoffman vacuum system.

NEW FROM DU PONT RESEARCH

Remarkable resistance to ozone, aromatic fuels, and "sour gas" shown by new **FAIRPRENE**® diaphragm material

Now, Du Pont announces the development of a new "Fairprene"† coated fabric for diaphragms. This new material shows remarkable resistance to swelling and deterioration in aromatic fuels, "sour gas" and under high ozone conditions—retains its properties from -65°F.

For further information about these "Fairprene" ozone and aromatic fuel resistant diaphragm materials mail the coupon below or write: *E. I. du Pont de Nemours & Co. (Inc.), Fabrics Division, Dept.* SA-94, *Wilmington 98, Delaware.*

CONSTRUCTIONAL AND PHYSICAL PROPERTIES††

Quality No. / FABRIC BASE	22-005FO NYLON	21-009FO COTTON	22-006FO NYLON
Thickness	.013"	.013"	.050"
Tensile Strength—Lbs./Inch, Min.	75 x 75	80 x 80	300+ x 300+
Tear Strength—Lbs., Trap., Min.	2 x 2	2 x 2	25 x 25
Burst Strength—PSI, Mullens, Min.	125	125	500
Ozone Resistance at 60 Parts Per Million*	OK 208 Hr.	OK 208 Hr.	OK 208 Hr.
Fuel Resistance—Volume Change after 72 Hrs. at Room Temp. in ASTM High Aromatic Fuel**	+3.3%	+9.4%	+20.9%

*Ordinary diaphragm materials fail in 15 minutes under this test.
**Ordinary diaphragm materials swell about 20% under the same conditions.
††The above data are based upon tests on production experience and should not be used as specifications.

†*"Fairprene" is Du Pont's registered trademark for its coated fabrics, sheet stocks and cements.*

DU PONT
INDUSTRIAL COATED FABRICS
SHEET STOCKS · CEMENTS

DU PONT
REG. U. S. PAT. OFF

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

▶ Mail coupon for free sample of new "Fairprene" ozone and aromatic fuel-resistant diaphragm material . . .

E. I. du Pont de Nemours & Co. (Inc.)
Fabrics Division, Dept. SA-94, Wilmington 98, Delaware

☐ Please send free sample of new "Fairprene" diaphragm material with high ozone and aromatic-fuel resistance.

☐ Please send bulletin on "Fairprene" industrial coated fabrics.

Name_____ Position_____

Company_____

Address_____

City_____ Zone____ State_____

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Some Ideas

for your file of practical information on drafting and reproduction from

KEUFFEL & ESSER CO.

One of the ways to judge a skilled craftsman is by the tools he uses. They're invariably the best he can find – chosen to lighten his work, sharpen his skills. And, if the craftsman is a draftsman, they are, more often than not, products of K&E.

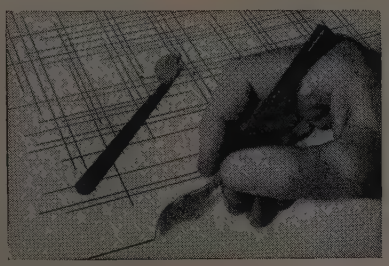
It may be that some of these products have escaped your attention (after all, we offer something over 8000 items). That's why we suggest you pay a visit to your K&E dealer whenever you can. It's a liberal education on what's new – as well as what's tried and true – in drafting equipment.

You'll find many products like these which can be highly useful in your work . . .

K&E "Quick Set" Bow Compass

The most remarkable feature of this compass is the speed and ease with which you can change settings—from diameters of 12 inches to 1/16 inch. With one hand, you can increase or decrease radii instantly and exactly. To go from small to larger radius, just press a spring release, and the legs will expand automatically. Stop approximately where you want, and make precise adjustments with a micrometer screw. To go from large to small, simply squeeze the legs of the compass together, then adjust precisely.

The K&E Quick Set combines the rigidity and precise adjustment of a standard bow compass, the simplicity and speed of a friction type compass, plus the finger tip control of K&E's unique design. You have to try the Quick Set to appreciate it fully. Two types are available. The N1071 fixed leg pencil compass, and the N1070 combination with interchangeable pen and pencil inserts. Both come with a box containing leads and spare needles. And with the N1070, a pen handle is provided for the pen insert which permits its use as a ruling pen. The compass can also be used as a divider by substituting one of the spare needle points for the lead in the pencil insert.

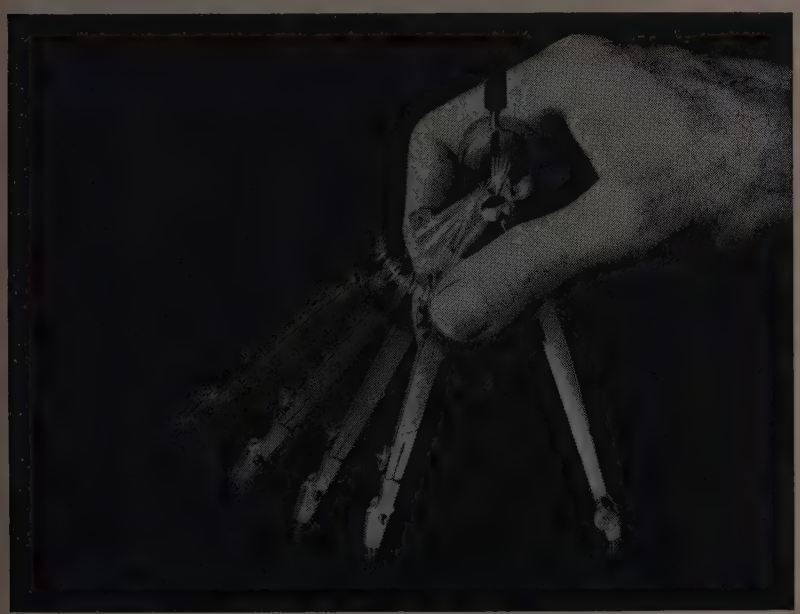


Marathon® Ruling Pens

K&E Marathon Long Line and Wide Line Ruling Pens (1092) hold an extra large ink supply – draw lines up to eight times longer than ordinary ruling pens. And because they are pre-set, line widths are always uniform, easy to match with complete accuracy. Ink flow is regular and even, lines are always sharp and clean edged.

An important feature of K&E Marathon Ruling Pens is that they will *not leak*. They can be laid on the work surface without risk of ink flowing out. That means you can fill several pens of different widths, use them as freely as you'd use pencils. They're easy to clean, too.

K&E Marathon Long Line Ruling Pens are available individually in line widths of .006, .009, .013, .020 inch – or in sets of three pens in line widths of .009, .013, .020 inch in a Leatherite case. Marathon *Wide Line* Ruling Pens come in line widths of .030 and .060 inch.



Leroy® Height and Slant Control Scriber

A versatile new Leroy scriber is now available which greatly expands the variety of lettering possible from a standard Leroy template.

Now, with the new Height and Slant Control Scriber (3237-12), you can form characters from vertical to slanting at any angle up to 45° forward. You can vary height from 60% to 150% of the size of letters on the template used. The width of letters remains the same.

Combinations of height and slant can be set quickly and easily. You just loosen the knob, move the scriber arm to the desired combination of height and slant, and tighten. That's all there is to it.

Stop in to see your nearest K&E dealer and ask to see these three products—small, perhaps, but mighty handy in the drafting room. Or drop us a line by mailing the coupon below . . .

KEUFFEL & ESSER CO., Dept. AA-4, Hoboken, N. J.

I'd like more information on:

- ☐ K&E Quick Set Compass
- ☐ Marathon Ruling Pens
- ☐ Leroy Height and Slant Control Scriber
- ☐ Please send me the name and address of my nearest K&E Dealer.

Name & Title_____

Company & Address_____

_____ 1613

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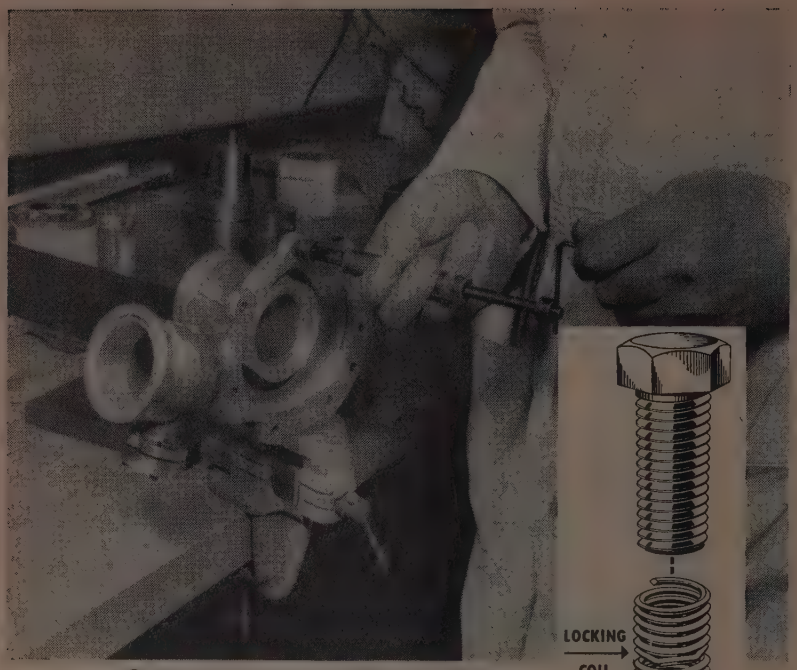


Heli-Coil® Stainless Steel Screw-Lock Insert is easily wound into tapped hole in lightweight aluminum housing. Spring tension of the locking coil retains screw securely, meets military specifications for locking torque and vibration.

How Carrier Corporation

Saves 40% in weight • 30% in assembly time

...with *HELI-COIL*® SCREW-LOCK INSERTS*

Use of aluminum lightens Carrier refrigeration system in Douglas DC-8 Jetliner

To reduce weight in the refrigeration system designed for air conditioning the giant Douglas DC-8 Jetliner, Carrier engineers used aluminum alloy compressor castings. To obtain maximum performance and reliability of threaded connections exposed to heat and vibration encountered at 600 mph, they selected the ***Heli-Coil*** stainless steel wire thread, *internal locking* Screw-LOCK Insert.

The results: design simplified, boss areas minimized, weight reduced as much as 40%, lock nuts and lock wiring eliminated. Now one man assembles the entire unit in 30% less time than before ... and danger of thread failure and screw loosening has ended!

Manufacturers in every field are relying on one-piece, stainless steel ***Heli-Coil*** Screw-LOCK Inserts to meet torque and vibration specs... protect threads against wear, stripping, galling and corrosion... save costs, space and weight. *Patented

HELI-COIL CORPORATION
DANBURY, CONNECTICUT

HELI-COIL CORPORATION *104 Shelter Rock Lane, Danbury, Connecticut*
I'd like more information on *Heli-Coil* Screw-LOCK Inserts

NAME_____TITLE_____
FIRM_____
ADDRESS_____
CITY_____ZONE____STATE_____ 1588

IN CANADA: W. R. WATKINS CO., Ltd., 41 Kipling Ave., S., Toronto 18, Ont.
Write in No. 118 on Reader Service Card at start of Product Preview Section

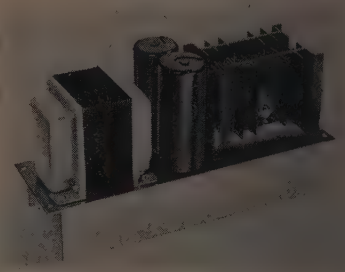
SWITCH is very small

A 1/28-oz, snap-action, electrical switch with case dimensions of .5 x .35 x .2 in. has a rating of five amps at 250 V ac and 30 V dc, says **Micro-Switch Div., Minneapolis-Honeywell Regulator Co., Dept. S/A, Freeport, Ill.** The Type SX subminiature unit permits the mounting of ten switches to the square inch.

The spdt switch has an operating force of six oz, maximum, and a release force of one oz, minimum. Case, cover and plunger are made of high-strength plastic. Contacts are of silver and the snap-action spring is made from beryllium copper.

Write in No. 219 on Reader Service Card

POWER SUPPLIES are fully transistorized



These sub-chassis units are designed for use as componenets in original equipment. Seven voltage ranges are provided—from 5-7 V at three amperes up to 27-32 V at one ampere. Regulation of the units (line load combined) is 0.5 per cent. Maximum transient (no load to full load) is 200 mv says **Dressen-Barnes Corp., Dept. S/A, 250 N. Vinedo Ave., Pasadena, Calif.**

Units are short-circuit-proof. The ripple is two mv rms. Maximum operating temperature is 50 deg C. The supplies can be operated in series to obtain higher voltages. Dimensions are 4 x 12 x 6¼ in.

Write in No. 220 on Reader Service Card

SILICONE LAMINATE in economy grade

Dilecto GB-89S is an economy-grade silicone laminate that combines high resistance to heat, flame, arc and moisture with good electrical and mechanical properties, says **Continental-Diamond Fibre Corp., Dept. S/A, Newark, Del.** It may be used for terminal, mounting and spacer blocks for motors and generators; coil separation in dry-type transformers; terminal boards and switch bases in electronic equipment; and power devices, such as switchgear and electric welders.

The laminate is available in sheets or molded shapes.

Write in No. 221 on Reader Service Card

more on page 254

PROTECT AGAINST CORONA, HEAT AND ALTITUDE . . .

AMP's new Post Insulated Stratotherm Terminals and Splices are designed for gruelling circuit environments "upstairs." Post Insulated Stratotherm overcomes difficult heat and high altitude problems confronting aircraft and missile enginering . . . combine the outstanding electrical performance of compression crimping with the new insulating qualities of sealed Teflon* sleeves which deter corona effects and moisture entrapment in a wide temperature range.

UPSTAIRS . . . WHEN THE HEAT'S ON

OUTSTANDING FEATURES:

- temperatures as high as 500°F
- fits varying insulation diameters in a wire size range from #22 through #10 AWG
- crimped insulation ring seals termination point against corona and moisture
- high flex and impact strength
- crimp attachment by either A-MP portable power tool or manually operated A-MP hand tool

*Du Pont Trademark

Complete technical data available on request.

AMP INCORPORATED

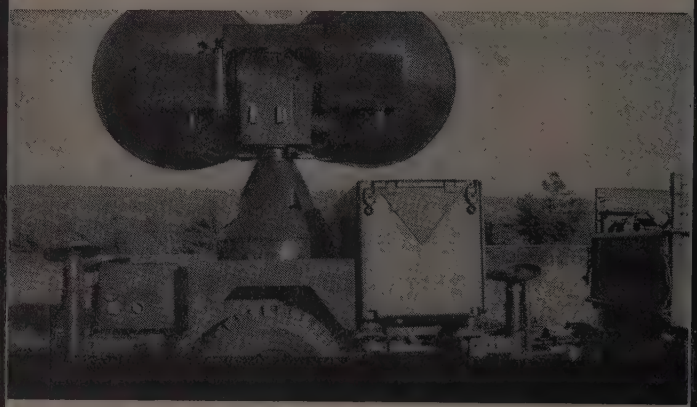
GENERAL OFFICES: HARRISBURG, PENNSYLVANIA

A-MP products and engineering assistance are available through subsidiary companies in: Canada • England • France • Holland • Japan

Write in No. 127 on Reader Service Card at start of Product Preview Section

COMBINE LIGHT WEIGHT WITH HIGH PERFORMANCE

. . . Bendix Radar Antenna Pedestals specified for "Hawk" missile system



To locate, track and destroy low-flying, high-speed attacking aircraft is the mission of the Army's "Hawk" missile system now in production by Raytheon Manufacturing Company, the prime contractor. Speed, accuracy and dependability are mandatory.

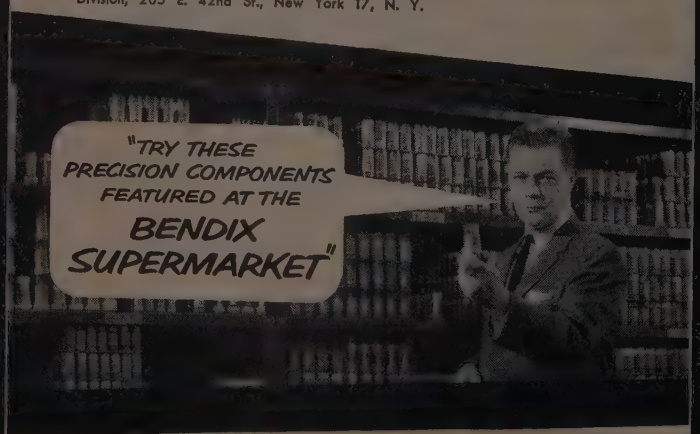
When Raytheon needed pedestals for the system's illuminator and acquisition antennae, Bendix had the answer—*a proved basic design that was readily tailored to the application at a great saving of time and money.*

The design combines the *reliability, high response* and *accuracies* (0.5 mil or better) of famed Bendix rotating components with the *ruggedness* of Bendix-designed and -cast magnesium housings. Experienced *component packaging* coupled with unique construction *save weight and space—ease transportation problems.*

THE "HAWK" PEDESTAL IS JUST ONE EXAMPLE from E-P's family of radar antenna devices developed for a variety of airborne and ground applications, including mortar and meteorological tracking, missile seeker and countermeasure types. Write for information.

Eclipse-Pioneer Division
Teterboro, N. J.
District Offices: Burbank and San Francisco, Calif.; Seattle, Wash.; Dayton, Ohio; and Washington, D. C. Export Sales & Service: Bendix International Division, 205 E. 42nd St., New York 17, N. Y.

Bendix
AVIATION CORPORATION



Write in No. 119 on Reader Service Card at start of Product Preview Section

DC MOTOR *has flat design*

A permanent-magnet, 1.7-oz dc motor that is 7/16 in. thick by 2 1/32 in. wide by 1 7/8 in. long has been designed to produce starting torques of up to 1.0 in.-oz, according to **Globe Industries, Inc., Dept. S/A, 1784 Stanley Ave., Dayton 4, O.** It is suitable for intermittent or continuous duty applications, and the flat design facilitates stacking.

Armature windings are available that enable the ball-bearing motor to accommodate various system voltages from three to 50 V dc. The device is made to withstand the effects of vibration and fungus, among other environmental conditions.

Write in No. 222 on Reader Service Card

DELAY LINES *for waveguides*

The input VSWR of these compact, light, and rugged units is less than 1.2 at any X-Band frequency, says **Turbo Mfg. Co., Dept. S/A, Lansdale, Pa.** Insertion loss is less than 0.1 db per foot of length.

A typical 1000-ft assembly at X-band has a diameter of two feet and is 15 in. high. Designs are available for assemblies of any length.

Write in No. 223 on Reader Service Card

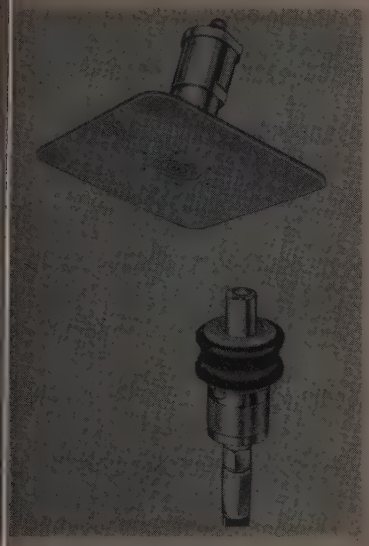
PRESET COUNTER *for up to 100 kc*

Model 7250 C has printed circuit plug-in modules that serve as separate counting decades and functional block units. The unit operates to 100 kc as a counter and will recycle without missing counts at rates up to 5 kc, says **Electro-Pulse, Inc., Dept. S/A, 11861 Teale St., Culver City, Calif.**

The instrument has high input sensitivity, pulse and variable duration, or locking relay contact output; and provision for electronic or switch gating of the input. Two-, three-, four-, and five-digit preset counters, dual preset counters, and totalizers are also available.

Write in No. 224 on Reader Service Card

COUPLING
is flush-mounted



A flush-mounted nipple and coupling that has an operating pressure of 4000 psi, and proof and burst pressures of 6000 and 10,000 psi, respectively, has been developed by **Airaterra Dept. S/A, 620 Paula Ave., Glendale 1, Calif.** Insertion to the stop point of the ground unit into the airborne section, followed by 90-deg clockwise rotation, provides a positive leakproof connection.

Both visual and audible indications inform the operator of a proper connection. Above a 100-psi line pressure, a pressure lock holds the collar in position. Sizes available range from ¼ through two in.

Write in No. 225 on Reader Service Card

VIBRATION METER
uses new technique

A new method of accurately measuring distances and vibration amplitudes from 50 uin. to 0.5 in. over the one-cps to ten-kc band has become possible through the Type B-731A vibration meter, says **Wayne Kerr Corp., Dept. S/A, 2920 N. 4th St., Philadelphia 33, Pa.** The meter operates by measuring, in terms of distance and peak-to-peak vibration, the capacitance created when a noncontacting probe is brought into proximity with the object under test.

In this technique, output is directly proportional to distance, and a linear relationship holds between capacitance change and distance. The meter can be used for remote testing of electronic components, measuring vibration in rotating shafts or bearings, production line tolerance checks, and the testing of airframe members. Probes are available for full-scale deflections of 0.001, 0.01, 0.1 and 0.5 in. A switch increases vibration sensitivity by a factor of fire. Accuracy is two per cent of full-scale deflection.

Write in No. 226 on Reader Service Card

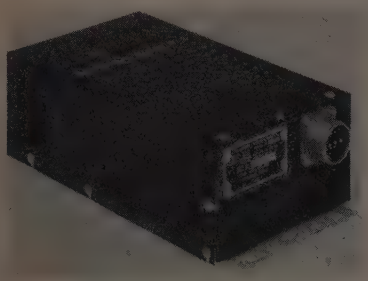
TERMINALS
have high voltage ratings

Press-Fit terminals utilize the insulating properties of Teflon to achieve ratings of 5500 V rms, 60 cps, or 13,000 flashover at sea level, says **Sealectro Corp., Dept. S/A, 610 Fayette Ave., Mamaroneck, N. Y.** These are at least 2½ times the usual ratings for miniature and subminiature types.

The terminals do not carbonize or form other products from decomposition during flashover or arcing. Thus successive arcing will not result in insulation loss. Other characteristics include a high surface resistivity.

Write in No. 227 on Reader Service Card

INVERTER
is transistorized



Model 4309 static inverter provides both single- and three-phase 400-cps power from 28 V dc input and controls the frequency to 400 cps ±0.1% from —55 to +71 deg C, says **Varo Mfg. Co., Inc., Dept. S/A, 2201 Walnut St., Garland, Texas.**

Using transistors in a bridge-switching circuit for reliability, 170-200 va of single-phase power and about 50 watts of three-phase power is obtained from the 9½-pound unit. Operation up to 71 deg C is attained without use of heat sinks or cooling air.

Write in No. 228 on Reader Service Card

POWER SUPPLY
is regulated

Model SR-1000, a solid state regulated dc power supply, is designed for strain gage excitation. The unit has a "floating" output that allows either side to be grounded, says **Video Instruments Co., Inc., Dept. S/A, 3002 Pennsylvania Ave., Santa Monica, Calif.**

The supply has less than 10 μv of noise from the dc output to ground when used with a grounded strain strain gage bridge of 350 ohms or less. Regulation is 0.1 per cent from 95 to 135 V. The voltage can be adjusted from five to 30 V by means of a potentiometer and range switch. Maximum output current is 1000 ma. Ripple is less than one μv. Leakage resistances is at leat 10,000 megohms.

Write in No. 229 on Reader Service Card

more on next page

P.S. and don't forget these other quality products at the

BENDIX "SUPERMARKET"

With our greater variety and greater volume of the precision components listed below, we have become the "supermarket" of the industry. We feature fast delivery and mass-production economy—plus the highest precision quality.

400-CYCLE SYNCHROS
(Frame sizes: 8, 10, 11, 15, 22)
Control Transformers • Differentials • Receivers • Resolvers • Transmitters

GYROS
Directional, Free, Rate, Roll and Vertical Gyro Transmitters • Stable Platforms

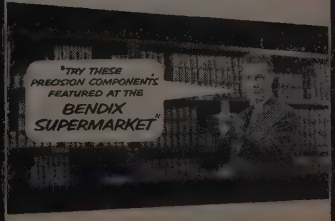
MOTORS AND GENERATORS
Gear Head Motors and Motor Generators • Low-Inertia Servo Motors • Motor Generators • Precision Induction Tachometer Generators • Rate Generators

PACKAGED COMPONENTS
Analog-Digital Converters • Azimuth Counters • Cam Compensators • Clutched Synchros • Dual-Speed Synchros • External Slip-Ring Synchros • Follow-Up Mechanisms • Miniature Differential Gear Assemblies • Servo Assemblies

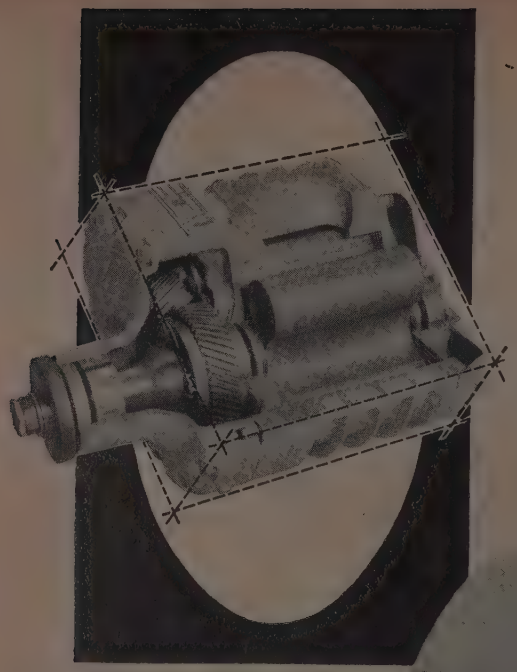
RADAR DEVICES
Airborne Radar Antennae

YCBTBS
You Can't Beat The Bendix "Supermarket". Try us.

Eclipse-Pioneer Division
Bendix AVIATION CORPORATION
Teterboro, N. J.



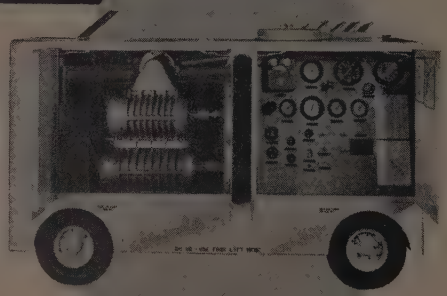
Write in No. 120 on Reader Service Card



delivers 1,000 cfm (up to 14 psig)

takes less than 5½ cu. ft.

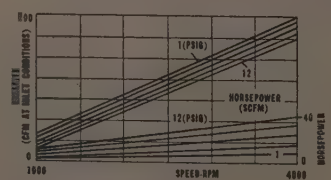
Arnolt Corp. Model CPT6-O TESTER, PRESSURE CABIN LEAKAGE (For Military and Civilian Aircraft)
Utilizes 2-stage M-D Blower Unit
1000 SCFM—10 PSIG
800 SCFM—12.5 PSIG
600 SCFM—14.0 PSIG



ARNOLT CORPORATION FINDS M-D ROTARY POSITIVE BLOWERS USE LESS H.P.— EFFICIENT AT WIDE SPEED RANGE

The Arnolt Corporation incorporates a 2-stage M-D Blower Unit in their CPT6-O cabin pressure leakage tester for several reasons. First, it delivers adequate CFM of air at the PSI required to do the testing job with ease, plus an average 50% reserve capacity; Second, the M-D 3-lobe rotary positive blower takes up less cubic space than any other unit of comparable performance; Third, it operates as efficiently at any speed or pressure; And finally, it can be operated with a smaller driver of less size and weight.

M-D Blowers operate at wider pressure and speed ranges than any other rotary positive blower. The capacity of the Model 4012 (4" rotor 12" long) is shown below. Capacities of 11 other production models range from 50 to 4000 CFM, pressures to 14 PSIG single, 70 PSIG multi-stage.



For full information write

M-D BLOWERS, INC., RACINE, WISCONSIN
A Subsidiary of Miehle-Goss-Dexter, Inc.

Write in No. 121 on Reader Service Card at start of Product Preview Section

LOCKING DEVICES are automatic

Automatic Locking Devices permit rotation of a unit from the input side, but prevent feedback from the output side. The shaft lock mounts at either input or output and is equipped with 4 miniature ball bearings for high speed application and where side thrust or input or output shafts exist, says **Automatic Locking Devices Inc., Dept. S/A, Box 32, Bridgeport, Conn.**

The purpose of the knob lock is to lock a shaft against its angular position, to lock the knob against accidental rotation, and to provide a slip clutch within the knob to prevent injury to equipment in the event of jamming. Both shaft and knob locks have inch ounce set and release provisions so that input-output parameters may be instantly controlled.

Write in No. 230 on Reader Service Card

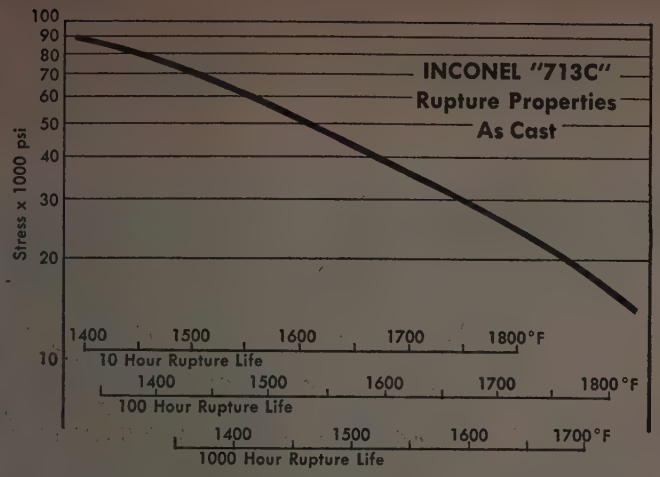
DELAY RELAY has instantaneous reset

The delay relays in the IT, TR, and STR Series will reset the instant they are deenergized, thus providing equal delay for each succeeding cycle, says **Eelectronics Div., Curtiss-Wright Corp., Dept. S/A, 260 Passaic Ave., West Caldwell, N.J.** Other features of the relays, which are designed for airborne applications, including missiles, are compensation for temperature and voltage, and resistance to shock and vibration.

Time delays are factory preset for between 20 and 180 sec, and the device is voltage compensated from 22 to 32 V dc with a nominal rating of 28 V. Temperature compensation is from —65 to 125 deg C, and the relay operates under vibration from 500 cps to 15 g's. It will also withstand a shock of 50 g for 11 msec. Operating power is ten W during timing and under three W after the timing interval.

Write in No. 231 on Reader Service Card

more on page 260



Graph shows the 10-hour, 100-hour and 1000-hour rupture strength that Inconel "713C" provides at 1700°F

New cast alloy! New rupture strength!

Now aircraft and missile designers have a new alloy to work with:— Inconel "713C"* nickel-chromium cast alloy.

Inco developed it especially for high temperature investment cast parts in advanced jet aircraft and missile hardware.

Basically, Inconel "713C" alloy combines outstanding rupture strength at 1700°F (see graph) with excellent resistance to thermal fatigue and good castability.

Other new high temperature alloys developed by Inco

In addition to Inconel "713C", Inco has developed a number of other new high temperature alloys which may well be the answer to material-selection problems in missile design. They include: Incoloy "T" titanium-containing nickel-iron-chromium alloy, Incoloy "901"* nickel-iron-chromium alloy, Inconel "700"* age-hardenable nickel-cobalt-chromium alloy and Inconel "702"* aluminum-containing nickel-chromium alloy. For comprehensive data on these new nickel alloys, write to:

*Registered trademark

THE INTERNATIONAL NICKEL COMPANY, INC.

67 Wall Street — New York 5, N. Y.

INCO TRADE MARK

INCO NICKEL ALLOYS

NICKEL ALLOYS PERFORM BETTER LONGER

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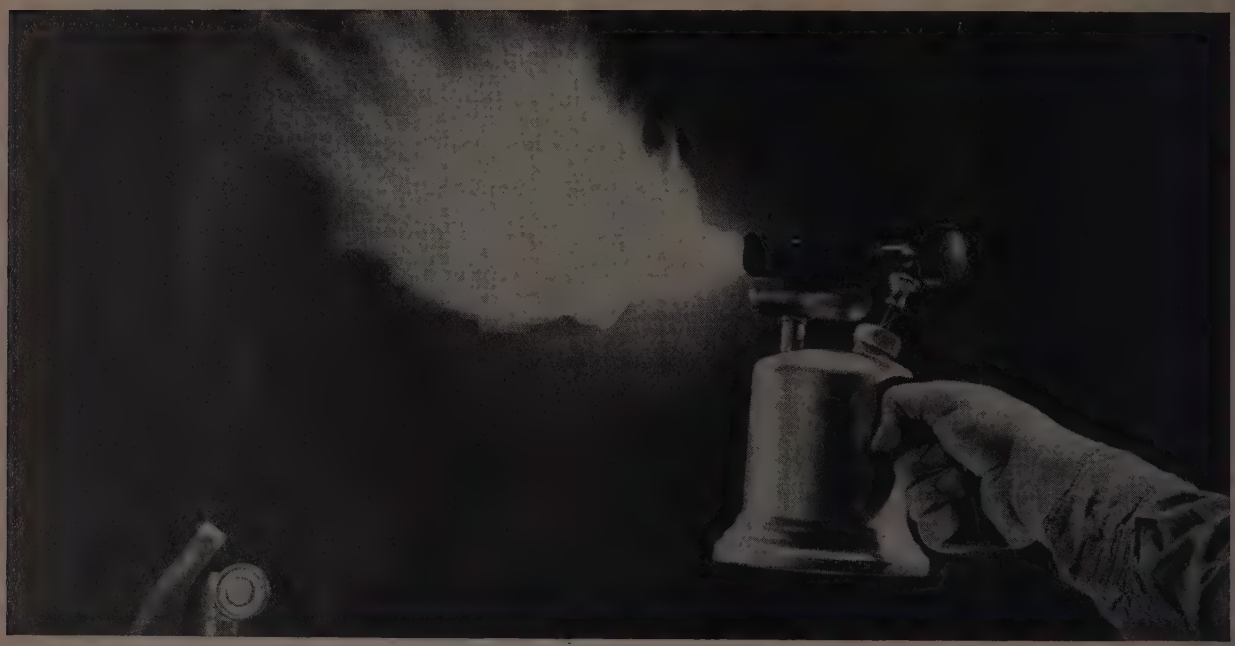
Why the new interest in flame retardance of plastic laminates?



Sheet of Synthane to which blowtorch is being applied

While it is unlikely you will ever take up your blowtorch to sample the flame resistance of laminated plastics, this property emerges as a lively topic for discussion among engineers.

Admittedly its import is for the councils of those whose equipment is flame-exposed or is powered, amplified or controlled by vacuum tubes and upon which, clustered or confined, you could properly fry an egg.

Under the circumstances, it is appropriate to ask what laminated plastics (or Synthane, to name our choice) have to offer in the way of flame retardance, and how this property relates to the other, and more widely used, advantages of laminates.

Two Specific Flame Retardant Laminates

There are two grades of Synthane laminates specifically earmarked for flame retardance—Grades FR-1 and FR-2. Except for its flame retardance, Grade FR-1 closely resembles standard paper base phenolic Grade XX Synthane. Grade FR-2 is similar to Grade FR-1, but may be readily hot punched and would be used where flame retardance with emphasis on punchability was desired.

Many Grades of Synthane Self Extinguishing

Many standard grades of laminates—though they contain no flame retardant additives—are self extinguishing. That is, they do not support combustion when the flame is removed.

For example, the fabric and glass melamine grades are excellent for their self-extinguishing characteristics. The same is true of the asbestos grades. Why, then, special flame retarding grades? The answer is partly financial.

The flame retardant grades FR-1 and FR-2 offer good electrical and mechanical properties (similar to Grade XX) plus excellent flame retardance and at a moderate cost. When the electrical or mechanical requirements are severe it is they that may control the choice of laminate even though flame retardance is still necessary. And it just so happens that the cost of producing grades with superior electrical and mechanical properties tops the cost of producing flame-retardant Grades FR-1 and FR-2.

Comparison of Properties of Synthane Laminates with Relation to Flame Retardance

	GRADES										
Property	FR-1	FR-2	XX	C	L	C-M	L-M	G-5	G-8	A-M	AA-M
Flame Retardance	E	E	P	P	P	E	E	E	E	E	E
Heat Resistance	F	F	P	P	P	G	G	E	E	E	E
Arc Resistance	P	P	P	P	P	E	E	E	E	E	E
Mechanical Strength	F	F	F	G	G	G	G	E	E	G	G
Dimensional Stability	F	F	F	F	F	G	G	E	E	E	E
Moisture Resistance	E	E	G	G	G	G	G	E	E	E	E
Dielectric Strength	E	E	G	F	F	F	F	E	E	F	F
Mechanability	E	E	E	E	E	E	E	F	F	F	F
Cost	Lowest	Lowest	Low	Low	Mod	Mod	Higher	Higher	Mod	Lowest	Higher

E=Excellent, G=Good, F=Fair, P=Poor

Obviously there is more to this business of selecting an electrical insulation than flame retardance. In any spot where flame retardance is a factor it is prudent to counsel with us, directly or through our representatives, to secure for yourself the Synthane Grade which supplies *all* of the properties you need *in combination* and at a reasonable cost. Our aim is to help you obtain the most for your money so that you may find coming to us a profitable habit.

For further information about Synthane standard or flame retardant grades write Synthane Corporation, 55 River Road, Oaks, Pa.

Flame retardant test on Synthane for switchgear application. Heat is supplied by coil encircling the sample. Temperatures up to 1600°-1800°F are measured with optical pyrometer.

SYNTHANE

CORPORATION, OAKS, PENNA.

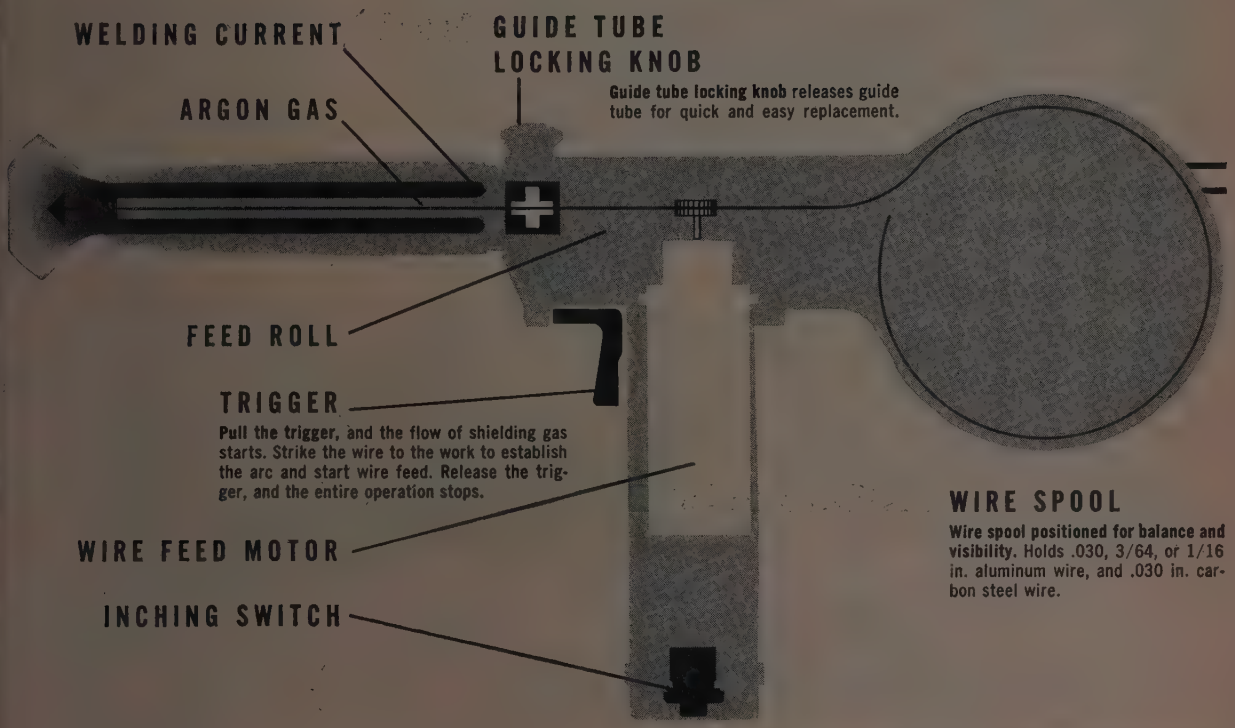
Laminated Plastics for Industry

Sheets, Rods, Tubes, Fabricated Parts
Molded-laminated, Molded-macerated

Write in No. 402 on Reader Service Card at start of Product Preview Section

Try LINDE'S New "SIGMETTE" Torch!

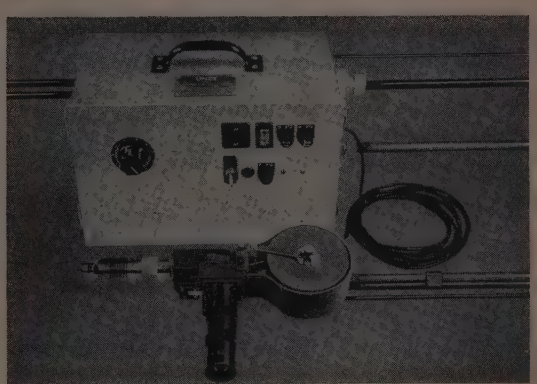
—PORTABLE, COMPACT


WELDING CURRENT
ARGON GAS
GUIDE TUBE LOCKING KNOB
Guide tube locking knob releases guide tube for quick and easy replacement.
FEED ROLL
TRIGGER
Pull the trigger, and the flow of shielding gas starts. Strike the wire to the work to establish the arc and start wire feed. Release the trigger, and the entire operation stops.
WIRE FEED MOTOR
INCHING SWITCH
WIRE SPOOL
Wire spool positioned for balance and visibility. Holds .030, 3/64, or 1/16 in. aluminum wire, and .030 in. carbon steel wire.

Here's the torch that goes to the job—lets you work in any position . . . in confined spaces . . . at distance remote from the power source!

Designed for Sigma welding of light metals, the "Sigmette" torch is compact and sturdy. Notice the thin silhouette and position of the spool for complete visibility. Torch and control are completely insulated and grounded—the operator is protected from electrically "hot" parts. And the only maintenance tool needed is a screwdriver!

Find out how Linde's new "Sigmette" torch can speed your operations, bring new economies through its advanced design features. For a free demonstration and detailed information, mail the coupon today or call the nearest Linde Office.



Complete unit—torch weighs 3 pounds, 1 oz.; control weighs 19 pounds, 2 oz.; Current rating, 125 to 200 amp.; Welding power, direct current reverse polarity

Dept. J-4, Linde Company
Division of Union Carbide Corporation
30 East 42nd Street, New York 17, N. Y.

☐ Please send complete facts on the new "Sigmette" torch.
☐ Please arrange to let me try it.

Name_____

Firm Name_____

Street_____

City_____ Zone_____ State_____

"Linde", "Sigmette" and "Union Carbide" are trademarks of Union Carbide Corporation.

Linde UNION CARBIDE

Write in No. 123 on Reader Service Card at start of Product Preview Section

project:
FUELING THE THOR—FASTER

FRI develops successful automated hookup and couplings for fast LOX and fuel transfer

Here, the problem was 5-fold. (1) Develop a flexible coupling for automated hookup. (2) Prevent leakage. (3) Protect vital internal parts from icing. (4) Provide high flow with minimum pressure drop. (5) Keep weight to a minimum.

Flight Refueling, Inc. solved it. The long experience of Flight Refueling, Inc. in developing, testing and manufacturing lightweight aerial systems, and the recent experience of designing components for the transfer of hydrocarbon fuels, LOX, H_2O_2, N_2, mercury and other nuclear reactor coolants, as well as heated gases, has resulted in the successful completion of many unusual projects.

If you are concerned with *fast fluid transfer,* remember this—FRI has the engineering imagination to design complete lightweight systems, and manufacturing facilities to produce in quantities such components as valves, couplings, nozzles, fittings and portable tanks. Write for literature.

Flight Refueling, Inc.
FRIENDSHIP INTERNATIONAL AIRPORT • BALTIMORE 3, MD.

West Coast Representative: William E. Davis, Box 642, Inglewood, Calif.

Write in No. 124 on Reader Service Card at start of Product Preview Section

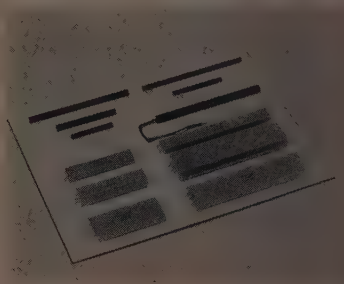
TACHOMETERS for integration

These servo motor-tachometer for precise integration range from size 11 (1.062 in. dia) to size 20 (1.950 in. dia), says **Kearfott Co., Inc., Dept. S/A, 1378 Main Ave., Clifton, N.J.** These components exhibit features such as a high degree of output voltage linearity, no frequency change between input and output voltages, stable output voltages over the temperature range specified, and extremely low harmonic distortion of output voltages.

Typical linearities of output voltages range from 0.03 to z0.10 per cent.

Write in No. 242 on Reader Service Card

DELAY LINES in standard cases



Type 25E, 25F, and 25G delay lines are available in a variety of standard case styles, including hermetically sealed cans and epoxy-encapsulated sticks, permitting either plug-in or pig-tail mounting. The delay periods range from 0.05 to one microsecond per six-inch length, according to **Technitrol Eng. Co., Dept. S/A, 1952 E. Allegheny Ave., Philadelphia 34, Pa.**

Standard tolerance on delay time is ±5%. Sveral windings ma ybe cascaded to produce longer delay periods. Special units are available that will meet all military specs.

Write in No. 243 on Reader Service Card

CONVERTER for frequency to dc

This frequency to dc converter provides a dc signal which is linearly proportional to the frequency of the input signal. Applications include the conversion of flowmeter, tachometer and other variable frequency signals to analog form, says **Nacimco Products, Dept. S/A, 2300 National Ave., National City, Calif.**

Model Cr 801 has a signal voltage input of —15 V ±5 VRMS nominal; signal frequency input of 0-500, 0-1000, 0-2500, 0-5000 nominal; input impedance is greater than 100K ohm; linearity is better than one per cent above 20 cps. It meets MIL-E-5272A for environment.

Write in No. 244 on Reader Service Card

more on page 262

Write in No. 125 on Reader Service Card➔

ANOTHER NEW AIRCRAFT COMPONENT MADE OF BYERS AMBALLOY STEEL

MBALLOY HIKES CAPABILITIES OF VITAL PARTS

How technically competent is your source of aircraft quality steels? Byers Amballoy steel users are served by trained metallurgists. Amballoy is uniform in workmanship, quality and cleanliness. Amballoy cuts rejections, improves product performance, meets exacting requirements.

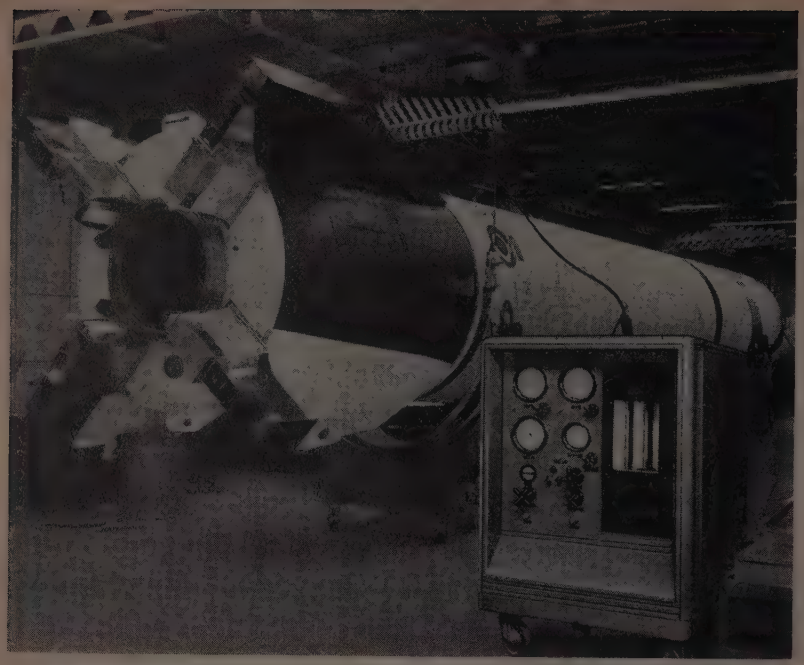
Evaluating materials for ultra-critical aircraft and missile applications? Consider Amballoy. Byers high-quality specialty steels boost performance of gear blanks, motor hubs, upset sections, tension rods, screw shafts, steering knuckles, piston assemblies, high stressed latch and catapult hooks, flanges, and gusset plates. Versatile Amballoy is increasing payload factors in scores of longitudinally and transversally loaded parts. For details, write: A. M. Byers Company, Clark Building, Pittsburgh 22, Pennsylvania.

Mighty mite. This straight bevel gear for power unit of Hiller Helicopter has a workhorse assignment demanding plenty of strength and stamina. Made of AISI-E 9310 Byers Amballoy Steel to Specification AMS 6260E at Vard, Inc., Pasadena.

aircraft quality steels from a technically competent source

A. M. BYERS COMPANY

Write for Reader Service Card at start of Product Preview Section

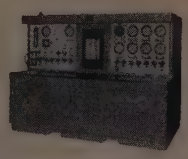


RELIABILITY—

verified by Nankervis test equipment ... from design to count-down

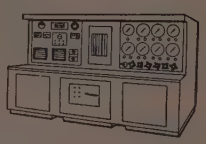
In the manufacture and check-out of missiles, accurate testing verifies fulfillment of military specifications at Chrysler Corporation Missile Division. Pictured above is a Nankervis portable power package currently being used to test Jupiter and Redstone hydraulic systems.

Nankervis combines technical knowledge and experience to build a wide range of hydraulic test and ground support equipment for use throughout the missile industry. In the assembly of this equipment, Nankervis directs special attention toward contamination control, high-pressure sealing and other problems associated with missile testing.



Universal Hydraulic Component Test Stand, Model 9500

Mobile Field Hydraulic Support Cart, Model 9462



Universal Servo-Valve Analysis Console, Model 9793 (available Spring 1959)

Portable Fluid Filtration Cart, Model 9545

Send for brochure on standard and custom built missile test equipment.

GEORGE L.

NANKERVIS

COMPANY

15800 FULLERTON AVENUE, DETROIT, MICHIGAN

Write in No. 126 on Reader Service Card at start of Product Preview Section

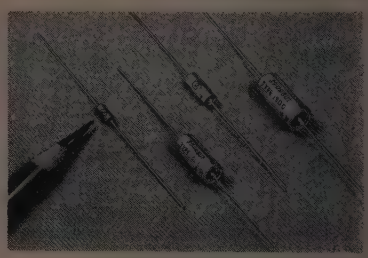
VACUUM RELAY for high voltages

The smallest relay yet designed for high voltage and high current operations is useful for radar pulse-forming networks, and aircraft rf and dc circuits requiring high voltage insulation, says **Jennings Radio Mfg. Corp., Dept. S/A, P.O. Box 1278, San Jose, Calif.** The 2½-in-long RBI has a voltage rating of ten kv and a continuous current rating of 15 amps rms.

Contacts of the vacuum relay need travel only 1/64 in. to hold off high voltage, a feature allowing construction of very small, efficient actuating mechanisms. Slightly larger multiple pole relays with 15-kv voltage ratings are also available.

Write in No. 245 on Reader Service Card

CAPACITORS are solid tantalum



The addition of two more case sizes to its type 150D series of Solid-Electrotype Tantalex Capacitors increase the range of maximum capacitances now available, says **Sprague Electric Co., Dept. S/A, 295 Marshall St., North Adams, Mass.**

The capacitance values added range up to 330 μF at 6 volts, 220 μF at 10 volts, 150 μF at 15 volts, 100 μF at 20 volts, and 47 μF at 35 volts. The entire series can be operated at temperatures up to 125 deg C with appropriate voltage derating. In addition, 10 precent EIA series nominal capacitance ratings have been added to previous listings.

Write in No. 246 on Reader Service Card

MICROWAVE ABSORBER for high temperatures

Eccosorb HT is a series of broadband microwave absorbers useful from —70 to +1200 deg F. It finds particular application for lining metal housings used to cap radiating antennas. Exact power handling of it is dependent upon the heat transfer situation. A typical value is 50 W/sq in., says **Emerson & Cuming, Inc., Dept. S/A, 869 Washington St., Canton, Mass.**

Eccosorb HT comes in light weight unicellular foamed ceramic bricks, that can be stacked on one another to produe a self-supporting wall, or they can be set into a housing with mortar. The bricks will not burn.

Write in No. 247 on Reader Service Card

more on page 264

(left) Navy Polaris AX-1 flight test vehicle at beginning of launch. Lockheed's Polaris fleet ballistic missile is more than a year ahead of original schedule.

(below left) One of the Santa Cruz test stands with dynamic thrust mount to simulate flight environment. Vibration oscillator functions during static firings.

(below right) Large centrifuge for environmental testing has unique shaker attachment to provide vibration simultaneously with high G-loadings.

TEST / Expanding the Frontiers of Space Technology

Testing is a vital part of every stage in the development of missile and space programs at Lockheed Missiles and Space Division.

The Division maintains one of the most completely equipped missile and space test laboratories in the world. Equipment includes: altitude, temperature and humidity chambers; shaker and vibration systems; G-accelerators; and apparatus capable of performing chemical, metallurgical, plastic, heat transfer, hydraulic, pneumatic, shock, acceleration, sinusoidal and random vibration, structural, electrical, and electronic tests. Static field testing; research and development testing on controls; testing in ordnance and hydraulics and high-pressure gas and propulsion systems are conducted at the 4,000 acre, company-owned test base in the Ben Lomond mountains near Santa Cruz, California.

As weapon systems manager for such major, long-term projects as the Navy Polaris FBM; Discoverer Satellite; Army Kingfisher; Air Force Q-5 and X-7; and other important research and development programs, Lockheed is engaged in expanding the frontiers of technology in all areas.

Flight testing is conducted at Cape Canaveral, Florida; Alamogordo, New Mexico; and Vandenberg AFB near Santa Maria, California; in a unique manner. All components and sub-systems of a new project are initially tested on known-performance, production missiles. Thus, when the final system is ready for first flight, its individual components already have flight-tested reliability. This new concept of flight testing is a major contribution and has enabled Lockheed to produce extremely complex missile systems in record time and at greatly reduced expense.

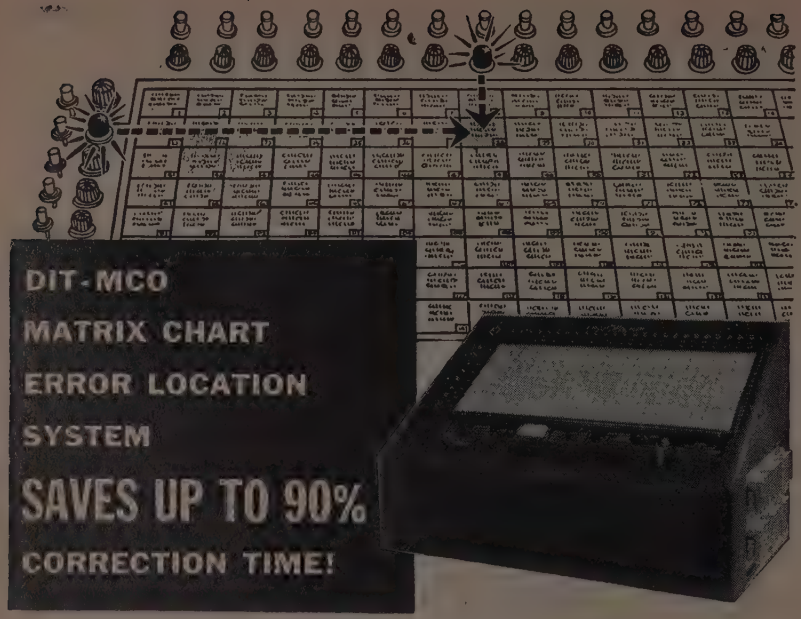
Underwater launch tests—including studies of cavitation, wave simulation and skip motion—are carried on at the Sunnyvale facility and at the Navy test base on San Clemente Island. In addition, structural and other tests are performed at Hunter's Point Naval Shipyard, California.

If you are experienced in any of the various phases of testing, we invite your inquiry. Positions also are available in physics, mathematics, chemistry, or one of the engineering sciences. Write: Research and Development Staff, Dept. D-11, 962 W. El Camino Real, Sunnyvale, California.

"The organization that contributed most in the past year to the advancement of the art of missiles and astronautics." NATIONAL MISSILE INDUSTRY CONFERENCE AWARD

Lockheed / **MISSILES AND SPACE DIVISION**

SUNNYVALE, PALO ALTO, VAN NUYS,
SANTA CRUZ, SANTA MARIA, CALIFORNIA
CAPE CANAVERAL, FLORIDA • ALAMOGORDO, NEW MEXICO

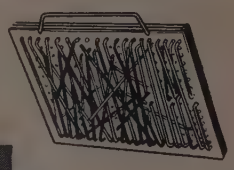


Pinpoints All Circuit Flaws Instantly...Plots and Simplifies Test Procedure...Provides a Permanent Record!

DIT-MCO's revolutionary Matrix Chart is the only error location device which puts all circuit information . . . errors, circuit numbers, type of flaws, etc. . . . directly in front of the operator of this Automatic Electrical Circuit Analyzer. It plots the entire test sequence and pinpoints every circuit flaw . . . instantly! Horizontal and vertical indicator lights cross reference to indicate the exact error location, circuit number and type of flaw. As errors are detected, they are recorded on the proper matrix square and the test continues.

Once the test sequence has been completed, all corrections are made direct from the Matrix Chart. This *group correction* feature saves up to 90% of error correction and/or interpretation time by eliminating time-consuming searches through complex manuals and wiring diagrams. After corrections have been noted on the Matrix Chart, it provides a complete record of test circuits, test specifications, instructions, results and modifications. This concise, understandable record improves interdepartmental communications and provides co-ordination through all stages of planning, production and maintenance. Non-technical personnel easily master operation of the Analyzer and use of the Matrix Chart System. The final Matrix Chart can follow the product for future overhaul and maintenance use.

DIT-MCO, Inc. employs an experienced staff of sales engineers in the field. Contact your field sales engineer or write for important facts about DIT-MCO Automatic Electrical Circuit Analyzers.



PLUGBOARD PROGRAMMING SPEEDS TESTING!

Jumper-wired plugboard programming permits use of simple, straightforward adapter cables. Circuit modifications never present headaches because all changes are easily made by re-jumpering the readily accessible plugboards.

DIT-MCO, INC.

ELECTRONICS DIVISION • BOX 04-11
911 BROADWAY • KANSAS CITY, MO.

Partial List of DIT-MCO Users

Aircraft Radio Corp. ● AiResearch Manufacturing Co. ● American Bosch Arma Corp. ● American Machine & Foundry Co. ● American Motors ● Amphenol Electronics Corp. ● Autonetics, A Division of North American Aviation, Inc. ● Bell Aircraft Corp. ● Bendix Aviation Corp. ● Boeing Airplane Co. ● Cessna Aircraft Co. ● Chance Vought Aircraft, Inc. ● Chrysler Corp. ● Convair ● Douglas Aircraft Co., Inc. ● Dukane Corp. ● Electronic Products Corp. ● Fairchild Aircraft Division ● Farnsworth Electronics Co. ● Frankford Arsenal ● General Electric Co. ● General Mills, Inc., Mechanical Division ● General Precision Laboratory, Inc. ● Goodyear Aircraft Corp. ● Grumman Aircraft Engineering Corp. ● Hazeltine Electronics Division, Hazeltine Corp. ● Hughes Aircraft ● International Business Machines Corp. ● Jefferson Electronic Products Corp. ● Lockheed Aircraft Corp., Missile Systems Division ● Martin, Baltimore ● Minneapolis-Honeywell, Aeronautical Division ● Motorola, Inc. ● Northrup Aircraft, Inc. ● Pacific Mercury Television Mfg. Corp. ● Radio Corp. of America ● Radioplane Co. ● Raytheon Manufacturing Co. ● Servomechanisms, Inc. ● Sikorsky Aircraft ● Sperry Gyroscope Co. ● Summers Gyroscope Co. ● Sun Electric Co. ● The Swartwout Co., Autronic Division ● Temco Aircraft Corp. ● Thompson Products ● Topp Industries Inc. ● Trans World Airlines ● U. S. Naval Air Station Overhaul and Repair Depots ● U. S. Naval Ordnance Laboratory, White Oak ● Vertol Aircraft Corp. ● Western Electric Co. ● Westinghouse Electric Corp.

Write in No. 129 on Reader Service Card at start of Product Preview Section

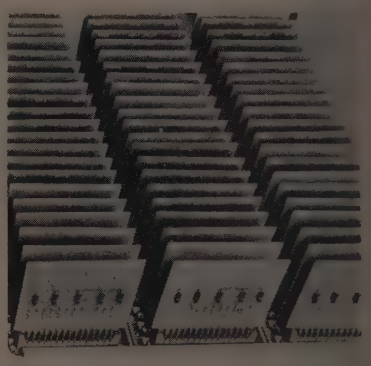
AIR COMPRESSOR *is engine-pad-driven*

This version if the Kidde 2 CFM, 3300 psi air compressor is engine pad driven. An unloaded valve automatically cuts out compressor when air storage bottle is built up to 3300 psi, cuts in compressor when pressure drops to 3100. Rotation can be clockwise or counter clockwise. Available with or without fan and self-contained lubrication system, says **Walter Kidde & Co., Inc., Dept. S/A, Belleville 9, N.J.**

Output of the unit at sea level is 1.9 CFM at 3200 rpm, and 2.7 CFM at 4500 rpm. Weight: 9.8 lb.

Write in No. 248 on Reader Service Card

DIGITAL LOGIC UNITS *are solid state*



A complete set of solid state digital logical packages can be combined to build registers, counters and other data handling equipment, including computers. The units include flip-flops, inverters, gates, drivers, and clock generators. The low cost plug-in modules are easily replaceable and can be built into systems of any size, says **Packard-Bell Computer Corp., Dept. S/A, 1905 S. Armacost Ave., Los Angeles 25, Calif.**

High reliability is achieved through the elimination of both eyelets and printed circuit connector.

Write in No. 249 on Reader Service Card

more on page 266

FIRST RULE
FOR
DELEGATING
GROUND
SUPPORT
EQUIPMENT
RESPONSIBILITY:

FIND AN AUTHORITY

Through 70 years of war and peace, St. Louis Car has developed, tested and built transport and handling equipment . . . railroad stock . . . amphibious vehicles . . . aircraft . . . special-purpose carriers and mounts.

Use this experience when you need transport and handling equipment, engineered from the systems approach to meet the specific operational objectives of your weapon.

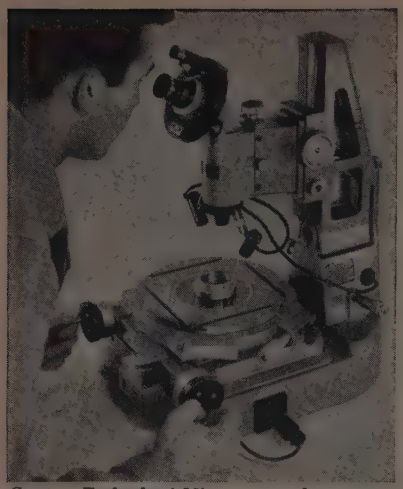
Before you assign any transport and handling equipment work—from R&D to production—evaluate St. Louis Car. We welcome the chance to submit proposals.

ST. LOUIS CAR COMPANY

St. Louis 15, Mo.

Write on your letterhead for Information Kit SA-11.

Write in No. 131 on Reader Service Card at start of Product Preview Section



Gaertner Toolmakers' Microscope used to measure typical piece part. Co-ordinate range 4" x 2".

Precise measurement to 0.0001" and 1 min. of arc

Gaertner Toolmakers' Microscope

Here is a reliable, easy-to-use microscope for precise measurement of piece parts, tools, dies, thread gages, templates, jigs, fixtures, etc. Ideally suited for making a wide variety of precision measurements and is especially valuable in reducing rejects in production work.

With the Gaertner Toolmakers' Microscope you make direct, non-destructive measurements — no contact, no distortion, images are sharp and clear. It is a basic measuring instrument for inspection depts., gage labs, tool and die and model shops, industrial and research labs.

The Gaertner Toolmakers' Microscope has been proven in use by U. S. Government Gage Laboratories, and by prime contractors and their subcontractors. With all parties using the same measuring instrument, inspection procedures are co-ordinated and disagreements and rejects minimized.

Features that help you get
HIGH SETTING AND REPEATING ACCURACY

- Low, compact built-in rotary stage reads to 1 minute of arc throughout 360° range.
- Minimum overhang of stages.
- Full 2" precision-lapped lead screws with correction device.
- Straightforward, direct, uncomplicated optical system.

Features that assure you of
EASY, CONVENIENT OPERATION

- Independently rotatable cross hairs in protractor ocular speed up measurements, simplify measuring procedure.
- Convenient location of ocular eyepieces for ease of reading.
- Built-in transformer and plugs for all illuminators.

Modifications and accessories to
MEET YOUR EXACT REQUIREMENTS

- Thread and radius templates, camera and spotting attachments, fine motion focus, variable magnification available.
- If you have a special measuring problem, our staff of representatives will be happy to consult with you. The service and engineering facilities of the manufacturer are always immediately available to help you.

Write for Bulletin 147-56

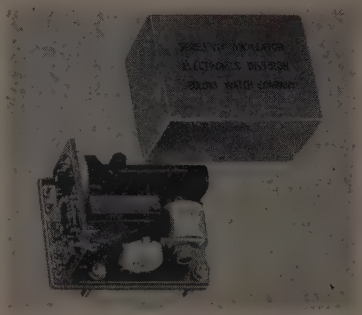
Designed and manufactured by

The Gaertner Scientific Corporation

1260 Wrightwood Ave., Chicago 14, Ill.
Telephone: BUckingham 1-5335

Write in No. 132 on Reader Service Card

VARIABLE OSCILLATOR is crystal-controlled



Type VCF variable crystal-concontrolled oscillators have automatic frequency control by application of an external voltage. Frequency range of the units is 10 kc to 20 mc, with variation up to six cps at 10 kc and 12 kc at 20 mc, according to **Bulova Watch Co., Electronics Div., Dept. S/A, 40-06 62nd St., Woodside 77, N. Y.**

The resolution of the shifts is infinite, depending on the stability and resolution of the modulating voltage. Drift, after stabilization, can be kept to less than one ppm. While temperature-controlled ovens are normally part of the VCF series, they are also available without ovens.

Write in No. 250 on Reader Service Card

MICROWAVE LEAK DETECTOR is portable

Model 646 portable power density meter was designed for surveying of high-energy fields near powerful microwave devices. It gives continuous direct reading of true power density in mw/cm^2 with an accuracy of —0 and +2 db, says **Sperry Microwave Electronics Co., Dept. S/A, Clearwater, Fla.**

The meter is available in three standard types to cover frequency ranges in S-, C-, and X-bands. Each type is self-calibrating and battery-operated. Total weight of the heaviest meter is six pounds, including batteries.

Write in No. 128 on Reader Service Card

more on page 268

NEW AGASTAT®

HAS LONGER OPERATING LIFE

The Agastat time/delay/relay has been completely re-designed, inside and out, to make every moving part last longer and operate more reliably. Here are some other important advantages:

- Dial adjustment for ease and accuracy
- Five timing ranges, covering an overall range of from 0.08 seconds to 15 minutes
- Timed intervals remain the same through repeated readjustments
- Integral wiring diagram and calibration plate
- Measures only 4-9/16 x 2-9/16 x 2-5/8"
- All contacts are flexible contacts
- Contacts are larger for fast heat dissipation

Write for details and application engineering assistance to Dept. A32-419.

AGA DIVISION

Elastic Stop Nut Corporation of America

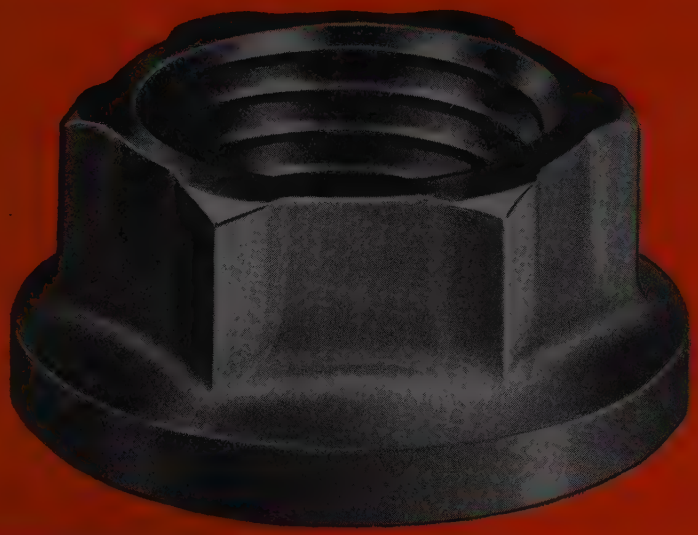
1027 Newark Avenue, Elizabeth, New Jersey

Pioneers in Pneumatic Timing

Write in No. 133 on Reader Service Card at start of Product Preview Section

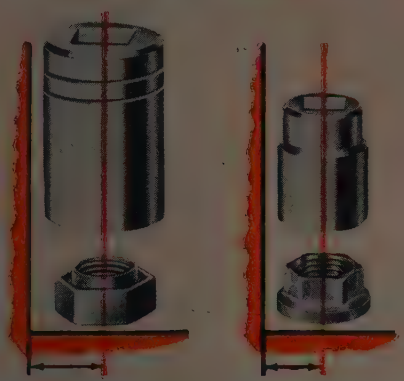
NEW KAYLOCK H-14!

First 160,000 PSI LOW HEIGHT Locknut



COMPARE WRENCH ACCESS

Standard Hex vs New H-14



See how new Kaylock H-14

- **Saves weight and space**
- **Brings bolt closer to load center line**
- **Permits narrower flanges**

It's another pace-setting development by Kaynar, who pioneered the first lightweight, self-locking nuts for airframes, missiles, jet engines and electronics.

The new Kaylock H-14 offers these exclusive advantages:

- 20% to 62% lighter than Kaynar's original H-10 hex nut series—smaller envelope dimension
- Tensile strength rated for 160,000 PSI bolts
- Uses two-size smaller sockets than for Standard AN and NAS nuts
- Nut and bolt can be moved closer to load center line
- Patented* Kaynar thin-wall, resilient self-locking device assures uniform locking torque
- Also available in A286 corrosion-resistant steel for 900°F

*Pat. No. 2,816,591 — Other Patents Pending.

KAYNAR MFG. CO., INC.—KAYLOCK DIVISION
Box 2001 Terminal Annex • Los Angeles 54, Calif.

Please send me a copy of your H-14 Brochure.

*Name*_____ *Title*_____

*Company*_____

*Company address*_____

*Home address*_____

*City*_____ *Zone*____ *State*_____

Get ALL the facts about the new Kaylock H-14. Fill in and mail coupon now!

Trade Mark

KAYLOCK®
All-Metal Self-Locking Nuts

KAYNAR MFG. CO., INC. — KAYLOCK DIVISION

Home office and plant: Write Box 2001, Terminal Annex, Los Angeles 54. Branch offices, warehouses and representatives in Wichita, Kansas; New York, New York; Atlanta, Georgia. Canadian Distributor: Abercorn Aero, Ltd., Montreal, Quebec.

© Kaynar Mfg. Co., Inc., 1959

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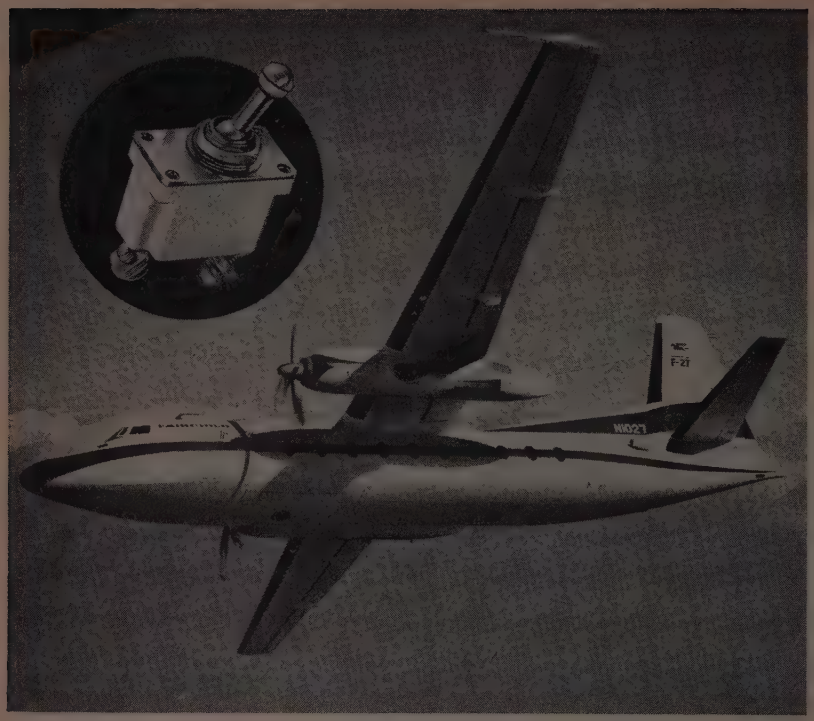


FAIRCHILD F-27

Klixon D7270 switch-type Circuit Breakers Mounted in Panel

equipped with KLIXON Switch-type Circuit Breakers

for Dependability and Proven Record of Operations

Soon leading airlines, as well as air-minded corporations, will fly with propjet comfort in the Fairchild F-27.

Among the many components that add to the F-27 safety and dependability are KLIXON switch-type Circuit Breakers used in the junction boxes in the tail, air-conditioning compartment, nacelle and flight station circuit breaker panels.

Here's what Fairchild has to say —

"Fairchild uses KLIXON *Circuit Breakers because we have found through past experience on other Fairchild aircraft that they are dependable with a proven record of operation; therefore, we use them with confidence and expectation of long service life."*

Write for Technical Data Bulletins giving complete details on KLIXON Circuit Breakers.

METALS & CONTROLS CORPORATION
Spencer Division
3704 Forest Street, Attleboro, Mass.
KLIXON®

Write in No. 135 on Reader Service Card at start of Product Preview Section

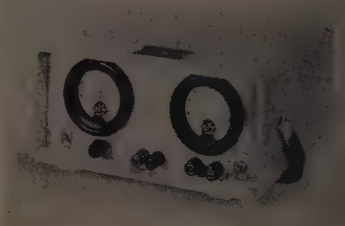
AXIAL-PISTON PUMPS are very efficient

The precise control of torque, acceleration, deceleration, speed or reversal is provided by these axial-piston hydraulic pumps and motors for land-based and shipborne missile ground support says **Vickers, Inc., Dept. S/A, Waterbury 20, Conn.** Overall mechanical efficiency of these units, which are made in a full range of pressures and hp sizes, is said to exceed 91 per cent at full load, and volumetric efficiency is 97 per cent at 3000 psi.

Transmissions are usually variable delivery pumps with axial-piston fixed-displacement fluid motors. Peak output is 3000 psi from 45 to 3600 hp.

Write in No. 251 on Reader Service Card

FREQUENCY-VOLT-METER in one package



Model 7500, a combination frequency and voltage meter, is designed for flight line use to check 400 cps power on airborne equipment. The unit has a frequency accuracy of 0.05% over the 110-120-V range, says **Varo Mfg. Co., Inc., Dept. S/A, 2201 Walnut St., Garland, Texas.**

Operating power of the unit is furnished from the point being measured. This same power provides the signals for simultaneous measurement of frequency and voltage while using a maximum of 100 ma current. The voltmeter has another scale with ±2% accuracy from 0 to 15 Volts. The unit performs from —55 to +71 deg C.

Write in No. 252 on Reader Service Card

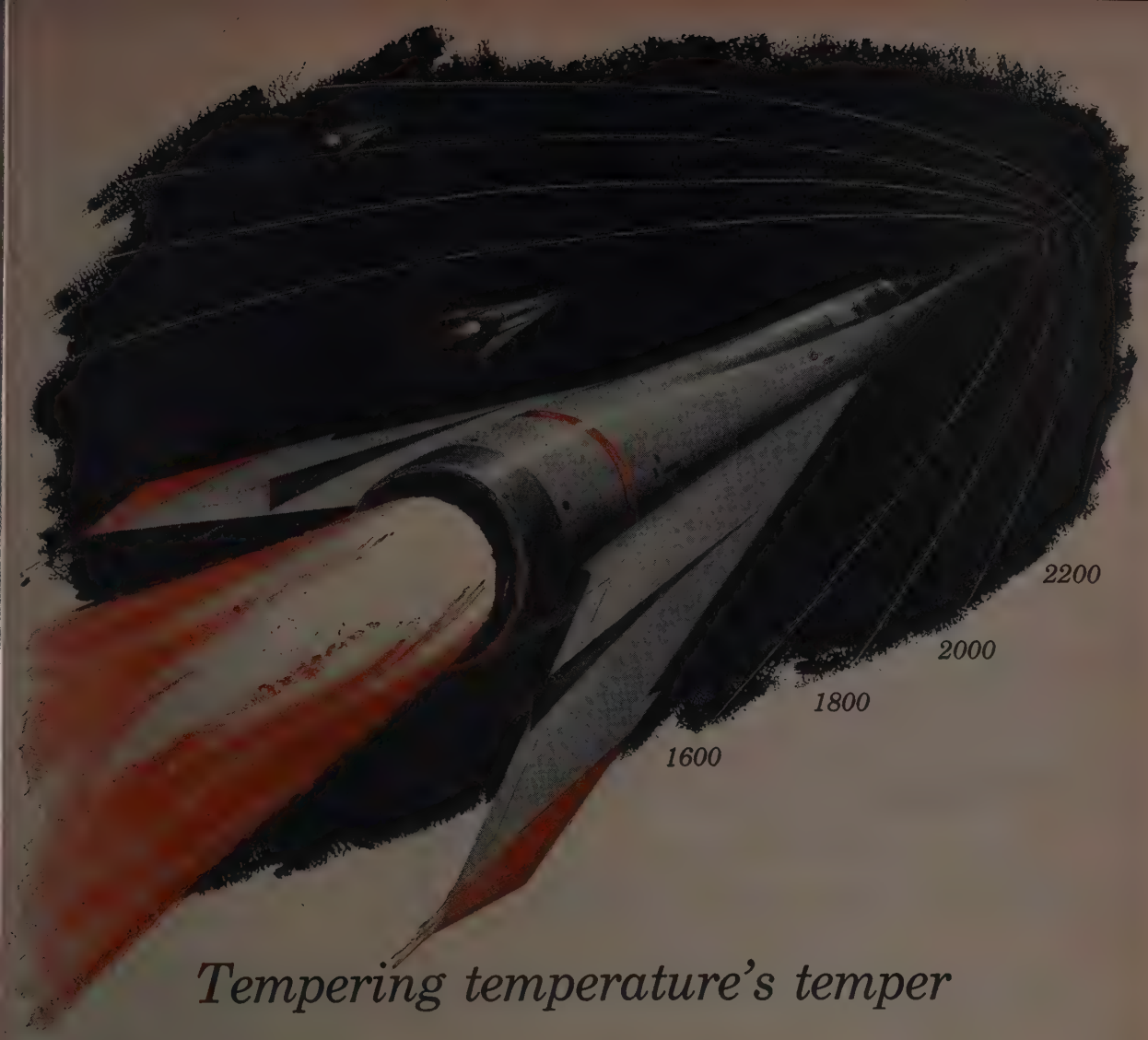
LUBRICANT in spray can

The lubricant Molylube is now being packaged in an aerosol spray can by **Bel-Ray Co., Inc., Dept. S/A, Madison, N.J.** It consists of a dispersion of a micro-fine molybdenum-disulfide an da carrier that is non-toxic, non-corrosive, non-inflammable, and free of any abrasive impurities or resins.

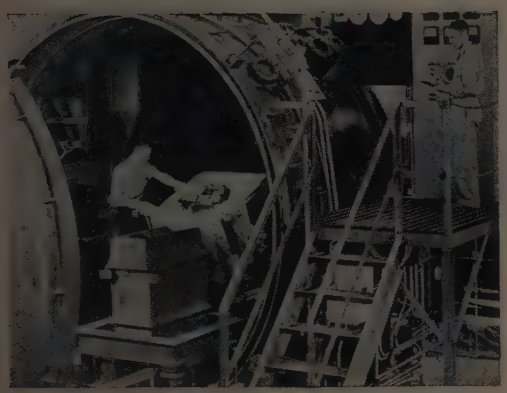
The dry solid-film lubricant spray resists the attack of most acids and is useful over a —100 to +750-deg F range. The lubricant can withstand pressures of over 100,000 psi, and it will reduce a bearing's coefficient of friction to that of the molybdenum-disulfide itself.

Write in No. 253 on Reader Service Card

more on page 270



Tempering temperature's temper



Complete vacuum melting equipment is part of HAYNES STELLITE's modern plant facilities. For full details, write for 48-page descriptive booklet.

Heat of 2000+ deg. F. is generated in a supersonic jet's tailpipe. So is extreme vibration.

By far the best alloy tested for this critical component is MULTIMET alloy—one of 12 HAYNES alloys helping combat heat, stress, and erosion in the jet engine, missile, and rocket field.

HAYNES alloys are relied on for use in afterburners, turbine blades, nozzle vanes, and many other high-temperature parts. All 12 HAYNES high-temperature alloys are *production* alloys and are readily available. Some are vacuum melted. Some air melted. Some are cast, some wrought, some are produced in both forms.

HAYNES
ALLOYS

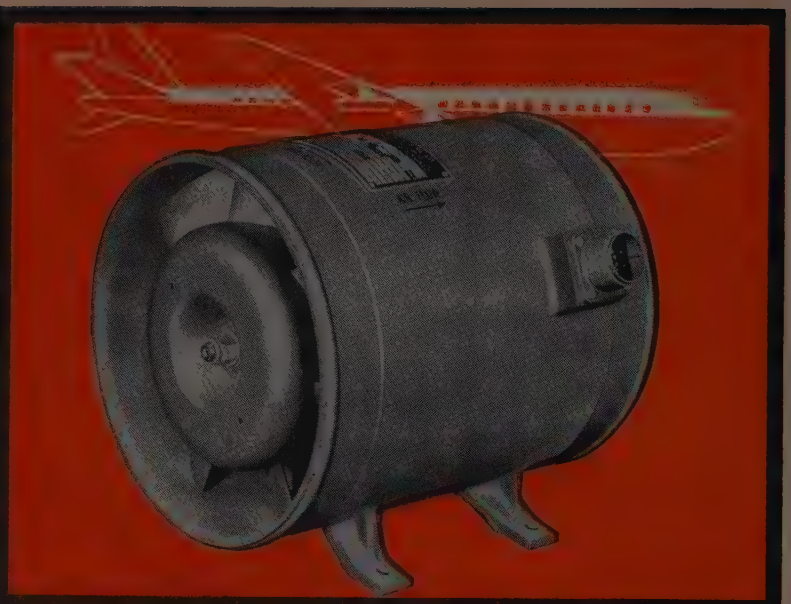
HAYNES STELLITE COMPANY
Division of Union Carbide Corporation
Kokomo, Indiana

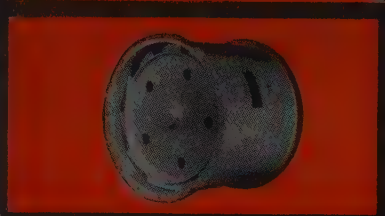
UNION CARBIDE

Address inquiries to Haynes Stellite Company, 420 Lexington Avenue, New York 17, N. Y.

"Haynes," "Multimet," and "Union Carbide" are registered trade-marks of Union Carbide Corporation.

Write in No. 136 on Reader Service Card at start of Product Preview Section





Design Flexibility with Economy

Choose from over 340 Standard Joy Axivane® Fans

Over 340 models with 1300 designs give the aircraft designer the flexibility of custom fans with the economy of standard fans. Horsepowers as low as 1/500th, fan efficiencies as high as 86%, and pressures up to 70" WG are available.

Joy Axivane Fans meet most applicable government specifications being used by a majority of airframe and missile manufacturers, including Boeing, Lockheed, Martin, Douglas and North American. Joy Axivane Fans have only three basic parts, and motors are flange mounted inside the fans to permit mounting in ducts. This simplicity of design makes the fans lightweight and compact, yet vibration and shock resistant.

Special designs to meet unusual requirements also can be furnished to your specifications. Whatever your air movement problems, Joy can provide the solution. **Joy Manufacturing Company, Oliver Building, Pittsburgh 22, Pa.** In Canada: *Joy Manufacturing Company (Canada) Limited; Galt, Ontario.*

Write For Free Twelve Page Catalog 266-38

JOY

WORLD'S LARGEST MANUFACTURER OF VANEAXIAL TYPE FANS

WSW I 7362-266

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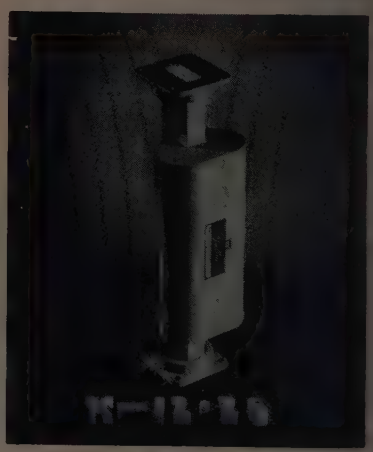
TRANSDUCER is variable inductor

For commercially available inductance and reactance controlled FM/FM subcarrier oscillator systems, this miniature, single coil, variable reluctance diaphragm transducer offers very low sensitivity to shock, vibration and acceleration, says **Ultradyne Inc., Dept. S/A P.O. Box 3308, Albuquerque, N.M.** The S-60 has a rise time of 75-150 microseconds for all differential, gage and absolute models offering a wide selection of pressure ranges between 0-10 and 0-5000 psi.

Standard deviation is ±7½% (±5# for all RDB bonds, unless otherwise specified by customer. Operating temperature is from —85 F to +240 F. The linearity is 10% and the correct deviation for sub-carrier oscillator type specified by customer. Basic size is ⅞" diameter by ⅞" long.

Write in No. 254 on Reader Service Card

LOAD ISOLATORS are broadband



These low power broadband Uniline ferrite load insulators can handle 10 W in forward direction and two watts in the reverse, says **Monogram Precision Industries, Inc., Cascade Research Div., Dept. S/A, Los Gatos, Calif.**

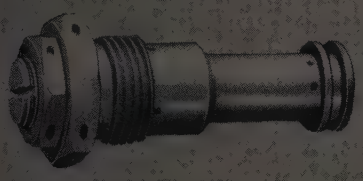
The insertion loss is 1 db maximum and the input VSWR into a flat load is 1.15 max. The six models cover frequency ranges from 5.85 to 12.4 kmc, with a choice of either 30 or 40 db isolation.

Write in No. 255 on Reader Service Card

more on page 272

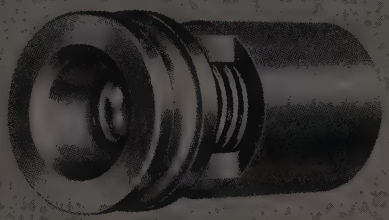
Cartridge or Modular VALVES

for dependable, precise flow and pressure control



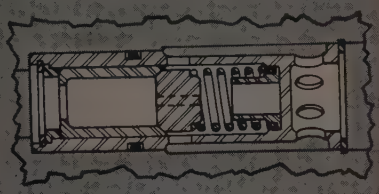
RELIEF VALVE
(Pilot Operated)

- Pressure Range: Adjustable to 4000 psi
- Capacity: To 27 gpm
- Weight: 4 ozs. in S.S.



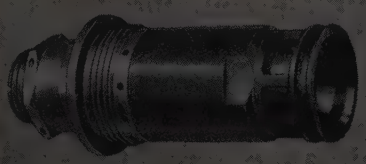
CHECK VALVE

- Flow: 11.5 gpm @ 3000 psi with 45 psi pressure drop
- Cracking pressure: 2 psi
- Weight: 2/3 oz.



FLOW REGULATOR

- Operating pressure: 1500 psi
- Reg. Flow: 1 to 12 gpm
- Weight: 4 ozs.

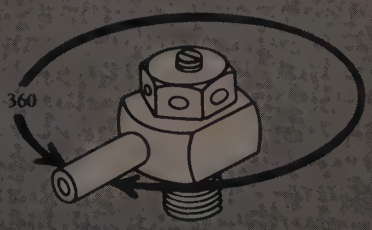


RELIEF VALVE
(Large Capacity)

- Pilot operated
- Pressure Range: to 500 psi
- Flow: 240 gpm
- Weight: 9 ozs.

MINIATURE CHECK VALVE

- Internal Leakage: Less than .5 dpm @ 900 psi in checked position
- Cracking Press.: 3 to 5 psi
- Flow: 3 gpm @ 900 psi with 10 psi pressure drop



BLEEDER VALVE

- Operating Pressure: 3500 psi
- Weight: 5/8 oz.
- Controllable Discharge

You can not afford to overlook these advantages:

- reduce size and weight
- eliminate leakage points
- save connectors, fittings and lines
- simplify maintenance (no lines to disconnect — just remove the valve from body)
- save installation time and costs
- permit greater design freedom (you can use two or more valves in a single body — in a manifold

We invite you to discuss your specific requirement with us. Write us today regarding your problem. Our specialized knowledge, design, testing and production facilities are at your disposal.

Designers and manufacturers of hydraulic and fuel valves for aircraft, missiles, rockets, ground handling and support equipment.

Fluid Regulators
CORPORATION

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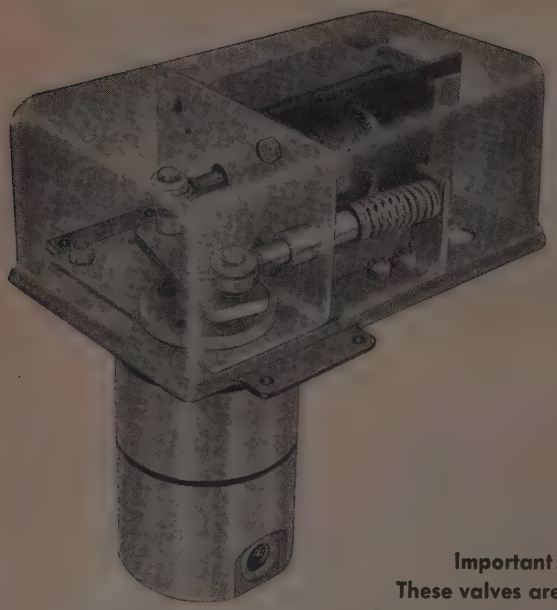
10,000 P.S.I. SOLENOID VALVES



Important: These valves are standard catalog items.

● They are available for immediate delivery (in stock) at standard valve prices, for a service which generally requires costly (made-to-order) special valves.

● Shut off and 4-way valves in ¼, ⅜ and ½ inch port sizes are rated for 10,000 P.S.I. liquid or gases. They will withstand surges of up to 15,000 P.S.I. without damage to the valves' sealing qualities (designed for a burst pressure of 30,000 P.S.I.).
Solenoids are available for 115, 230 and 460 volt A.C. operation.

● Long maintenance-free service is achieved through the leak-proof "Shear-Seal" design. Optically flat metal to metal sealing surfaces (of the self-aligning sealing rings and the mating rotor face) are protected by staying in constant intimate contact: flow is always through the center of the "Shear-Seals," never across sealing surfaces. Sealing qualities actually improve as the seals lap themselves to a more perfect fit with each valve operation. There is no external shaft leakage because the pressure is confined to the flow passages.

For complete data write for catalog S-10000.

CONTROL VALVE DIVISION

barksdale valves

5125 ALCOA AVENUE • LOS ANGELES 58 • CALIFORNIA

Write in No. 403 on Reader Service Card

RECORDER-REPRODUCER works with AM, FM, PWM

Model 1124 Tape Record-Reproducer is of modular design and ruggedly constructed for long service life. It performs with AM, FM and PWM as desired. Response range is from dc to 120 kc. Signal to noise ratio is better than 50 db on FM and 40 db on AM, says **Telectro Industries Corp., Dept. S/A, Long Island City 1, N. Y.**

The unit has a selection of six speeds from 1⅞ ips to 120 ips. It can record two to 28 tracks at the same time. Model 1124 is adaptable to telemetering or automation uses where very high speed and extreme precision are desired.

Write in No. 410 on Reader Service Card

SPHERICAL BEARINGS are cadmium plated

These spherical bearings are available in five series that cover radial static load ratings from 2700 to 104,000 lbs, says **Sealmaster Bearing Div., Stephens-Adamson Mfg. Co., Dept. S/A, Ridgeway Ave., Aurora, Ill.** The units are useful in aircraft applications.

The bearings include the SBG Series which features a cadmium plated outer race of aluminum bronze, and the SBG-SS, which has a heat-treated stainless steel outer race. Other series use heat-treated alloy steel, and carbon steels. The SBG type has a groove on the ball's id and an interconnecting oil hole.

Write in No. 411 on Reader Service Card

MINICUBE is miniature blower

The Minicube is a subminiature blower and motor combined in a rugged, compact one inch cube package. It weighs one ounce. Designed to produce three CFM, it includes a hysteresis motor operating at approximately 22,000 rpm on miniature precision ball bearings, says **Sanders Assoc., Inc., Dept. S/A, Nashua, N.H.**

The small size of the Minicube makes it suitable for mounting in subminiature equipment and in devices where space is at a premium. Two models are available for 400 cps power at either six volts or 26V. Each model can be connected for either single phase or two phase operation.

Write in No. 412 on Reader Service Card

ACCELEROMETERS are subminiature

Shock and vibration measurements of small components and systems are possible with the 600 Series accelerometers designed by **Columbia Research Laboratories, Dept. S/A, MacDade Blvd. & Bullens Lane, Woodlyn, Pa.** The 0.5-gram units have an acceleration range from one to 40,000 g, with a frequency coverage from five cps to 50 kc.

Each device is equipped with subminiature, low-noise cable, which minimizes spurious response of the test system that results from whipping effects and cable loading.

Write in No. 413 on Reader Service Card

POTENTIOMETER is gang type

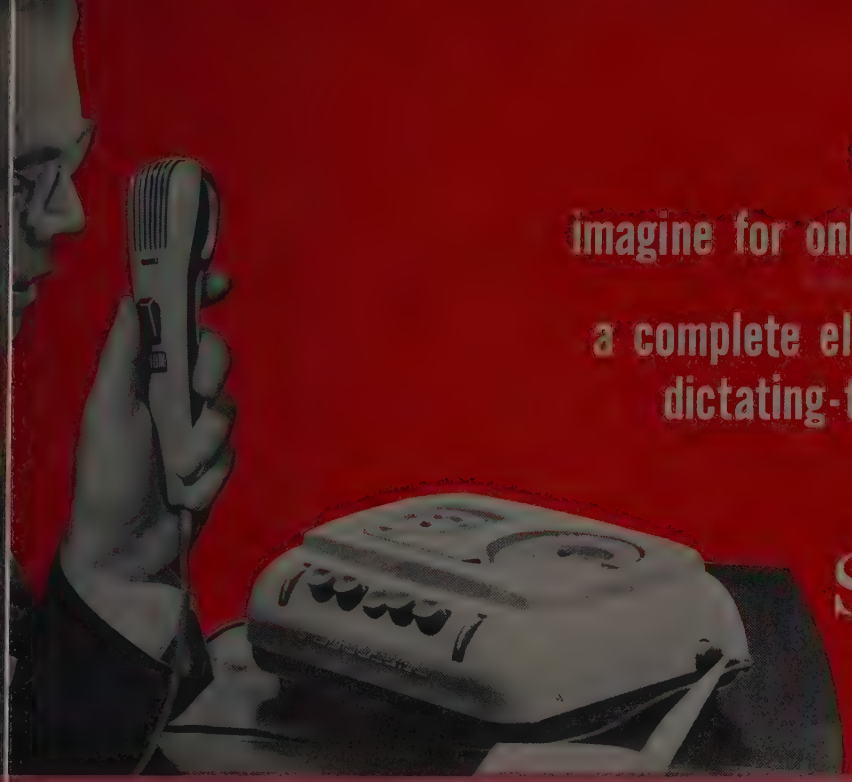
Model 319, a gang type potentiometer is available in resistance values up to 200 K ohms with a 0.05 linearity and a power output of 2 watts, says **Daystrom Pacific, Potentiometer Div., Dept. S/A, 9320 Lincoln Blvd., Los Angeles 45, Calif.**

The design of the unit allows phasing and rephasing of individual resistance wipers without disturbing settings of adjacent cups. The unit has a high temperature resistant plastic case and stainless steel mounts and ends. The potentiometer will meet MIL-E-5272A and MIL-STD-200.

Write in No. 414 on Reader Service Card

more on page 276

Write in No. 404 on Reader Service Card→



imagine for only $179.50

a complete electronic "all-in-one" dictating-transcribing machine

DeJUR GRUNDIG

Stenorette

More than 300,000 now in use.
DeJUR GRUNDIG **STENORETTE** carries the label of Underwriters' Laboratories. Your guarantee of the highest safety standards.

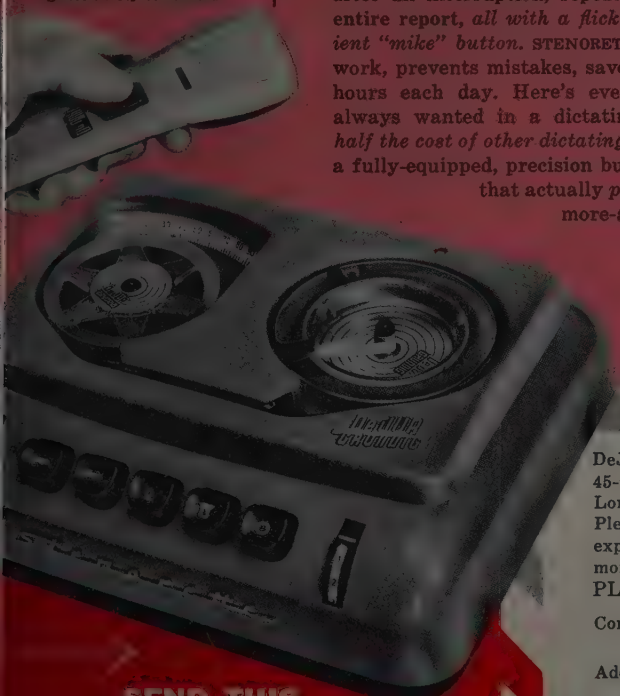
The Electronic Stenorette®

—the first really new dictating machine in 18 years!

Dictate, transcribe, erase, correct, start again after an interruption, repeat a word or an entire report, *all with a flick of the convenient "mike" button.* STENORETTE speeds your work, prevents mistakes, saves you valuable hours each day. Here's everything you've always wanted in a dictating machine—*at half the cost of other dictating machines!* It's a fully-equipped, precision business machine that actually *pays for itself* in more-accurate, faster on-the-spot operation!

MORE THAN 300,000 NOW IN USE! Executives everywhere prefer the STENORETTE to any other dictating machine *regardless of price.* STENORETTE gives you all the features of units costing twice as much – plus these advantages: Safety-control automatic error erasure, dual function dictator and transcriber, re-usable tape, and many others you can't get elsewhere at any price. COMPLETELY PORTABLE: weight 11 lbs. 10 oz. Just plug it in—at home, in office, even in a *moving car.* It's always ready when you are. PUSH-BUTTON CONTROL: easiest machine for you—and your secretary too!

® Registered Trade Mark



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Please rush, without obligation, a copy of your FREE BROCHURE explaining how the Stenorette can make my office work go faster, more efficiently, and more accurately.

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☐ Send me name of nearest Stenorette Sales/Service Center.
☐ Also send me details on the new DeJUR-TRIUMPH Typewriters.

AT LAST!

Push-Button error-free dictation at a price everyone can afford

HOW OFTEN have you seen a *price* in an ad for a complete dictating machine? Probably never. In fact, other manufacturers, realizing that their prices are so high, leave out all mention of purchase price or suggest that you can *rent* their machines. But you can own your Stenorette—because this electronic miracle sells for half the price of comparable major dictating machines. *It even costs less than a standard office typewriter!* That's why every office—even the smallest—can afford a Stenorette.

only **$179.50** plus F.E.T.

Transcribing accessories at slight extra cost.

COSTS LESS...ACTUALLY DOES MORE! Despite its amazingly low price, the world-famous Stenorette does everything the highest-priced units do—and more! It gives you every control, every time-saving convenience you can think of. And, because it's the most modern of all dictating machines, it's the easiest, simplest, fastest of all to use. Imagine! You dictate onto revolutionary magnetic tape—the finest medium for recording the human voice. And you erase with the *automatic* Safety-Control error erasure. Just re-record over the words to be corrected. You can dictate continuously up to 45 minutes. You never have to worry about expensive resurfacing and/or replacement needed for old-fashioned belts, discs, and cylinders. And Stenorette's foolproof PUSH-BUTTON CONTROLS make every step automatic.

FREE BROCHURE SHOWS HOW THE STENORETTE HELPS YOU "TALK" PAPER WORK AWAY.

Illustrated book *tells* and *shows* you how to do more really productive work in less time with the DeJUR Grundig Stenorette®. *Quantities are limited, so get your request into the mail now.*

DICTATE AND TRANSCRIBE WITH ONE MACHINE! A single Stenorette does it all. Just plug in the sensitive "mike" with finger tip Safety Control and dictate. Transcribing accessories designed for convenience and comfort of secretaries are used with same machine.

REALLY PORTABLE...WORKS ANYWHERE! Amazing Stenorette weighs only 11 pounds, 10 ounces, takes no more desk space than your briefcase. Stenorette's special design allows perfect operation in a moving car. (There's no "needle.") Exclusive "Conference" setting lets you record as many voices as you wish. Simple attachment lets you record telephone calls, too.

MOST SENSITIVE DICTATING MICROPHONE. Another Stenorette exclusive. Shout or whisper—hold the microphone wherever you wish. Your voice will play back clearly at its natural level.

USE THE SAME TAPE OVER AND OVER AGAIN! Dictate up to a full 45 minutes on miracle DuPont Mylar* tape. Transcribe. Start again with the same tape if you wish. Stenorette is as economical to use as it is to buy.

REMOTE-CONTROL ERASER! Make changes without touching the machine. Relax in your chair, press the button on the "mike," listen to your last words—and *record the correct words right over the error*, thanks to safety control erasure.

FOOLPROOF INDEXING! Typist knows exactly where to start listening, where to enter separately recorded changes, etc.

CHOICE OF TRANSCRIBING ACCESSORIES. Double or single earpieces. Playback control with bar on typewriter or pedal under desk.

WORLD'S EASIEST TRANSCRIBING. Tens of thousands of secretaries operated their Stenorettes flawlessly *within five minutes after their first trial.* All agree that Stenorette's clear, restful "playback" permitted rapid, error-free transcription!

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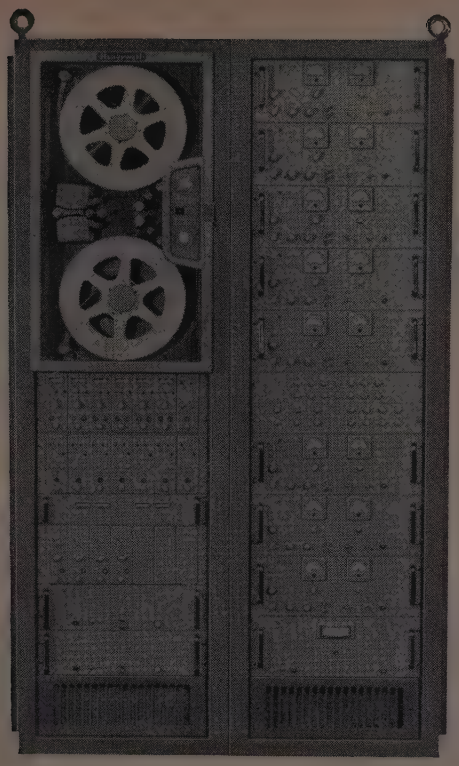

Honeywell
Series 3170

Wide Tape Systems
Lower Equipment Investment

From monitoring satellite signals to collecting rocket engine test data, Honeywell Series 3170 Magnetic Tape Systems are saving users money. The use of wide tapes, a Honeywell exclusive, makes it possible to collect more data with a given system. Frequently this eliminates the need for additional tape mechanisms . . . lowers equipment investment. Extra capacity is only one of many features available only from Honeywell. Here are others:

- Transport-mounted preamplifiers improve the signal to noise ratio at low playback speeds . . . eliminate strays and patching problems.
- Tapes as wide as two inches can be used to record as many as 40 tracks.
- Thin tape is run as easily and safely as standard tape.
- Standard transport is designed to handle 14 inch reels as well as 10-½ inch reels.
- Six tape speeds can be selected by simply turning a switch on the front panel.
- Tape width can be readily changed on the job.

All you buy is the equipment needed to meet your initial requirements. As your needs expand or change, plug-in interchangeable electronic modules make it easy to modify your Honeywell Series 3170 System.

Other mechanical and electronic features of the Honeywell Series 3170 Systems give you many additional advantages. Your Honeywell field engineer will give you the full story on a system tailored to your specific needs. He's as near as your telephone.

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Honeywell

First in Control

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marion
advancement in instrument design

actual size
Model HCM 7/16

MINIATURE 7/16" INDICATOR

Micro-miniature moving coil, core magnet indicator; 7/16" diameter, 31/32" length. Weight 10 grams; sealed. Available with a pointer or flag display in a wide variety of electrical sensitivities and functions. Data on request. *Marion Instrument Division, Minneapolis-Honeywell Regulator Co., Manchester, New Hampshire, U.S.A.*

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marion
"WHERE ELECTRONICS MEETS THE EYE"
meters

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TELEMETRY KEYER is subminiature

This subminiature pulse width modulator converts an amplitude-modulated pulse sequence to a pulse series of constant amplitude and variable width, says **Rotary Devices Corp., Dept S/A, 30 Joy St., Englewood, N. J.**

The output pulses are suitable for modulating a subcarrier oscillator or RF transmitter. The input impedance is five megohms shunted by 68 mmf, the linearity error less than one per cent, and the output amplitude is five volts p-p maximum. Dimensions are 3.6x1.4x2 in.

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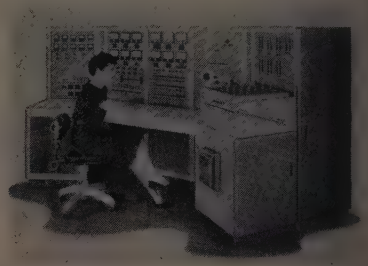
TUBE TESTER is automatic

Model 1128 tester performs complete dynamic tests on up to 25 tubes at a time, at rates of about 7-10 seconds per tube, according to **Jackson Electronic & Manufacturing Co., Dept. S/A, 695 Johnston St., Akron 6, Ohio.** The unit is designed to meet requirements of speed, accuracy, and



versatility for 100% reliability testing programs in critical military application.

The tester handles most pentodes, triodes, diodes, and neon regulators. Testing is determined on go-no go basis. Means are provided for pinpointing specific elements of tube failure. A totalizer indicates the number of tubes that fail to meet each test.

Write in No. 257 on Reader Service Card

more on page 278

Now-Specify VARFIL Sleeving and Tubing . . . and get these 5 BIG Advantages

HIGHER DIELECTRIC
[illegible]
MORE HEAT RESISTANCE
AVAILABLE IN COILS
CAN BE AFTER-TREATED

AVAILABLE IN FOLLOWING NEMA CLASSES
CLASS B-A-1 7000 VOLTS AVERAGE
CLASS B-B-1 4000 VOLTS AVERAGE
CLASS B-C-1 2500 VOLTS AVERAGE
CLASS B-C-2 [illegible]

Even under the most severe operating conditions, Varfil Sleeving and Tubing retains its average dielectric strength. Twist it, tie it, bend it, wrap it, knot it. Remains just as pliable as when you started. Won't crack, peel or suffer dielectric loss. Heat Varfil 2000 hours at 110° C.—1,000 hours at 125° C.—and even for extensive periods at 150° C. It won't break down. Can be after-treated in baking and varnishing operations. Reacts better than other oleoresinous materials and synthetic coated tubings. Available in handy coils so you can cut the exact lengths you need . . . no waste. Standard colors. Wide range of sizes. Exceeds or meets all A.S.T.M. specifications.

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Makers of Electrical Insulating Tubing and Sleeving
SEND TODAY FOR FREE SAMPLE FOLDER

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MINIATURE PRECISION BEARINGS INC.

Need More "Room" in Package Assembly Design?

MPB special bearings integrated with shafts or housings are real space savers . . . reduce tolerance troubles as well as torque. Solve many other "package" problems. Details from MPB, Inc., 1404 Precision Park, Keene, N. H.

MPB helps you perform miracles in miniaturization

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AIRBORNE RADAR...

The APS-67 Airborne Radar . . . designed and developed by *The Magnavox Company* in conjunction with the Navy Department, gives eyes that see by both day and night to the Crusader.

The APS-67 delivers the utmost in performance and reliability for this Navy Fighter . . . clearly demonstrating *The Magnavox Company's* ability to produce and work as prime contractor on a complex electronics project.

MAGNAVOX capabilities are in The Fields Of Airborne Radar, ASW, Communications, Navigation Equipments, Fusing and Data Handling . . . your inquiries are invited.

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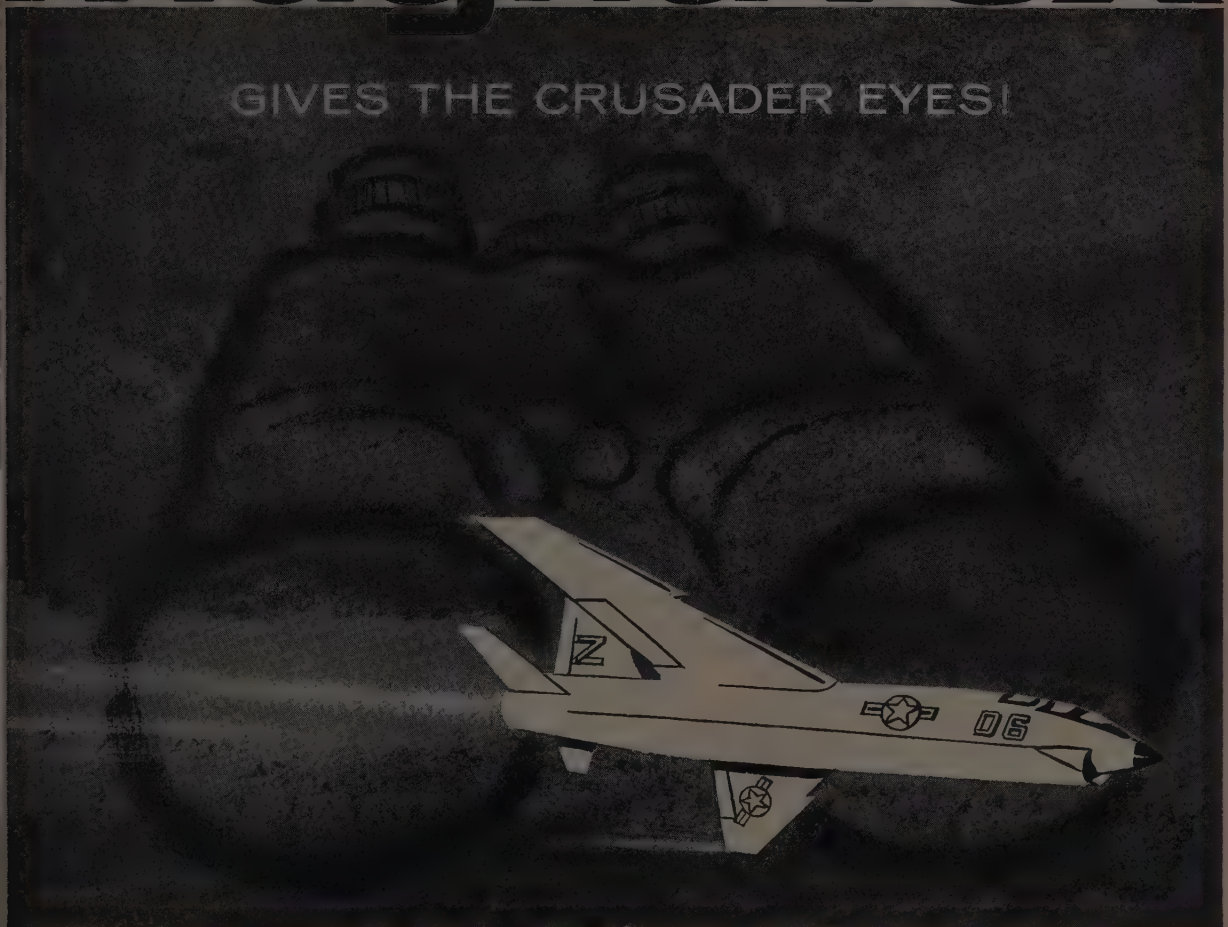
GIVES THE CRUSADER EYES!



COMMUNICATIONS | RADAR | DATA HANDLING | ASW | MISSILES

THE MAGNAVOX CO. • DEPT. 60 • *Government and Industrial Division* • FORT WAYNE, IND.

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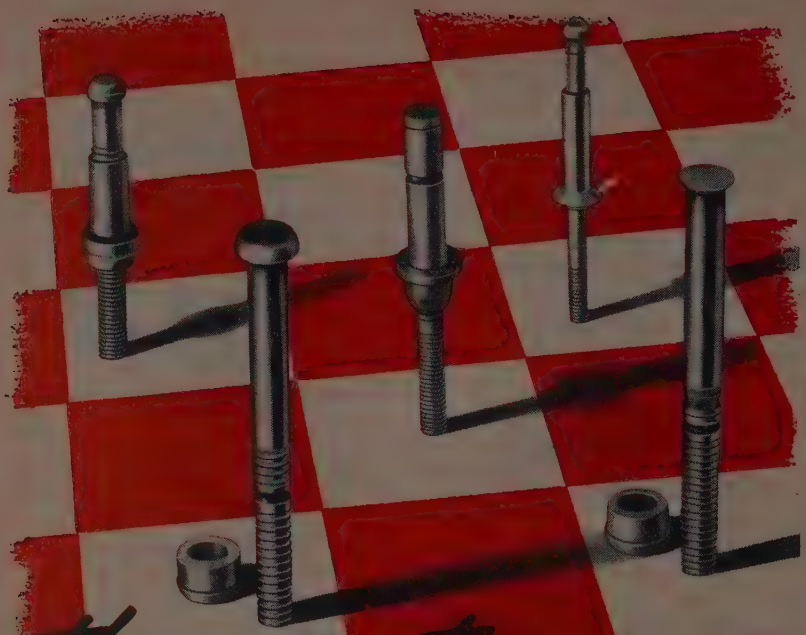
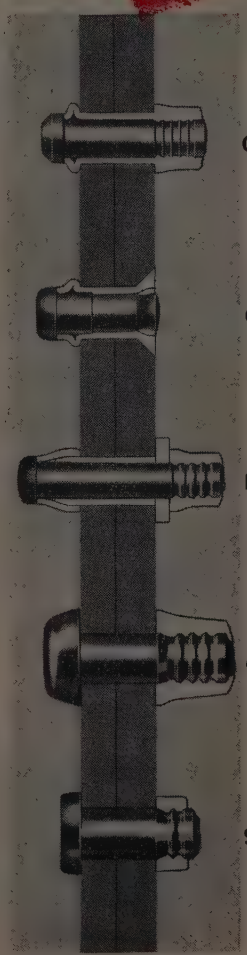


the smart move

is to **HUCK**

FASTENERS



Comments of regular users of HUCK FASTENERS tell the story.

"70% saving in our assembly cost".

"50% faster than previous methods".

"We use them wherever possible because of their strength and sealing qualities".

"Every fastener is automatically "torqued" identically".

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SOLENOID has rapid response

Type RS 5174 solenoid is designed to operate with a 24 lb load. The start of the 0.020 in. stroke occurs at a maximum of 14 milliseconds, and it completes its travel in less than 20 milliseconds from circuit closing, says **Telecomputing Corp., Telco Sales Div., Dept. S/A, 915 N. Citrus Ave., Los Angeles 38, Calif.**

The ambient temperature range of unit is from −65 to +160 deg F. Voltage rating is 24 V dc at 78 deg F. At this temperature, coil resistance is 19.2 ohms. Overall size is 1.65 in. high with a 2 in. dia case.

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MECHANICAL STOPS for rotary motion

These dimensionally identical devices, standard size 10 units, provide a means for stopping rotation at predetermined intervals. These mechanical stops are low inertia mechanisms having low starting friction yet high static torque, says **Kearfott Co., Inc., Dept. S/A, 1500 Main Ave., Clifton, N. J.**

Standard production stops are currently available as 15 or 30 turn models, and units can be supplied which are set to angles other than multiples of full turns. Full turn versions may be designed for any number of complete turns ranging from one through thirty.

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Write in No. 140 on Reader Service Card →

this is Cable Systematics

Advanced cabling techniques developed by Robertshaw provide the reliability demanded by today's complex missile site requirements. Whether your needs involve short lengths of custom multi-conductor cable or elaborate electronic *cable assemblies*, Robertshaw's progressive approach to cable design and fabrication mean *faster delivery* and *less cost*. Success of these concepts is being evidenced daily on the launching pads at Canaveral and Vandenberg. They can be adapted to help solve your cable assignment. Write for Cable Facility Brochure . . . **Aeronautical & Instrument Division, Robertshaw-Fulton Controls Company, Santa Ana Freeway at Euclid Ave., Anaheim, Calif.**

data preview

SYNCHROS—Synchros, servo motors, and transistorized amplifiers, all Size 8 devices, have been described in the four-page Bulletin 501A by **Norden Div., United Aircraft Corp., Dept. S/A, Commack, N.Y.** Specifications and outline drawings are given for such units as synchro transmitters, transformers, receivers, and differential transmitters, as well as for motors with high stall torque ratios and amplifiers with an 0.8 cu in. volume and a two-W power output.

Write in No. 260 on Reader Service Card

AIR CONDITIONERS—Separate information sheets on two types of mobile trailer-mounted, self-contained air conditioners have been published by **Hussmann Aircraft Div., Hussmann Refrigerator Co., Dept. S/A, 819 E. Taylor Ave., St. Louis, Mo.** Capacities of the Model HE-4A and HE-3A are, respectively, 149,000 and 138,000 BTU/hr net cooling at the duct outlet.

Write in No. 261 on Reader Service Card

FORMICA — A catalog entitled "Formica—Stronger Than Steel; Lighter Than Aluminum," which discusses the S-52 laminated plastic, has been prepared by **Formica Corp., Dept. S/A, 4614 Spring Grove Ave., Cincinnati 32, O.** The catalog points out that S-52 dies are faster and more economical to make, lighter in weight, and can be finished to a super-smooth, dent-resistant finish.

Write in No. 262 on Reader Service Card

TEFLON TAPE—Pressure-sensitive teflon tapes, suitable for electrical and mechanical applications over a —100 to +500 deg temperature range, are described in a four-page folder by **The Connecticut Hard Rubber Co., Dept. S/A, 407 East St., New Haven 9, Conn.** Temp-R-Tape, which has a chemical resistant facing, may be obtained in a thermal curing type.

Write in No. 263 on Reader Service Card

ROTARY ACTUATORS—A four-page, illustrated technical bulletin listing engineering information and dimensional data on a modular design rotary actuator, the Series R-12, has been issued by **Airborne Accessories Corp., Dept. S/A, 1414 Chestnut Ave, Hillside 5, N.J.** Bulletin MR-58 points out that any of 40 different packages may be made from 12 standard modular components.

Write in No. 264 on Reader Service Card

VALVES & FITTINGS—A detailed description of its full line of midget valves and fittings has been offered in Catalog 658 by **High Pressure Equipment Co., Dept. S/A, 1222 Linden Ave., Erie, Pa.** The units are made in a variety of designs and are used to provide minimum capacity in capillary and small-diameter high pressure tubing systems.

Write in No. 265 on Reader Service Card

CENTRIFUGE — Performance features and specifications of centrifuge acceleration test machines are included in a brochure entitled "Sky-High Tests on the Ground," available from **The Rucker Co., Dept. S/A, 4704 San Pablo Ave., Oakland, Calif.** Data on instrumentation, control and accessories are also considered.

Write in No. 266 on Reader Service Card

TERMINAL BLOCKS—An illustrated six-page brochure containing specifications and general information on terminal blocks for computer applications is available from **DeJur-Amsco Corp., Dept. S/A, 45-01 Northern Blvd., Long Island City 1, N.Y.** The solderless terminal blocks are designed to accept AMP 53 solderless taper pins.

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THERMOCOUPLES—Catalog 1885 is a 36-page publication covering the complete line of thermocouple assemblies and pressure sealing glands made by **Conax Corp., Dept. S/A, 2300 Walden Ave., Buffalo 25, N.Y.** Among the new items included are Type C bare wire thermocouple glands and roll temperature thermocouples.

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FILTERS—Two-mu filters have been described in a two-page data sheet (No. 100) by **Bendix Filter Div., Bendix Aviation Corp., Dept. S/A, 434 W. 12 Mile Rd., Madison Heights, Mich.** The filters are made for hydraulic fluids, fuels, lubrication oils, air, gases, and solvents.

Write in No. 269 on Reader Service Card

CONNECTORS—A revised catalog on the Continental Connector Series 20 miniature connectors has been released by the **Electronic Sales Div., DeJur-Amsco Corp., Dept. S/A, 45-01 Northern Blvd., Long Island City 1, N.Y.** The 40-page publication includes complete specifications, outline drawings, and illustrations.

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TEMPERATURE CONTROL — The Type B27A control, a calibrated control for air, gas or hot-plate applications and suitable for 180-deg ambient temperatures, is described in technical literature available from **United Electric Controls Co., Dept. S/A, 79 School St., Watertown 72, Mass.** Two completely separate switches permit switch action above or below the set point, control of two independent circuits, and flexibility of switching arrangements.

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MERCURY SWITCH—Data Sheet 149 provides characteristics and specifications of the AS419A1 miniature mercury switch made by **Micro Switch Div., Minneapolis Honeywell Regulator Co., Dept. S/A, Freeport, Ill.** The 1.8-g unit is said to offer long life, extreme compactness, sensitive operation and reliability in control device applications.

Write in No. 272 on Reader Service Card

ACCELEROMETER — Bulletin 1610 is a two-page description of the Type 4-260 accelerometer, a low-frequency acceleration measuring device made by **Consolidated Electrodynamics Corp., Dept. S/A, 300 N. Sierra Madre Villa, Pasadena, Calif.** The instrument uses variable reluctance to measure accelerations from zero to 100 cps, up to ±12 g's.

Write in No. 273 on Reader Service Card

PRESSURE PICKUP—The Type 4-340 sound pressure level pickup for high intensity noise contained in rocket and jet engines, a transducer with a 350-mv/psi, self-generating output, is described in Bulletin 1573A by **Consolidated Electrodynamics Corp., Dept. S/A, 300 N. Sierra Madre Villa, Pasadena, Calif.** The device has a response from 70 to 210 db.

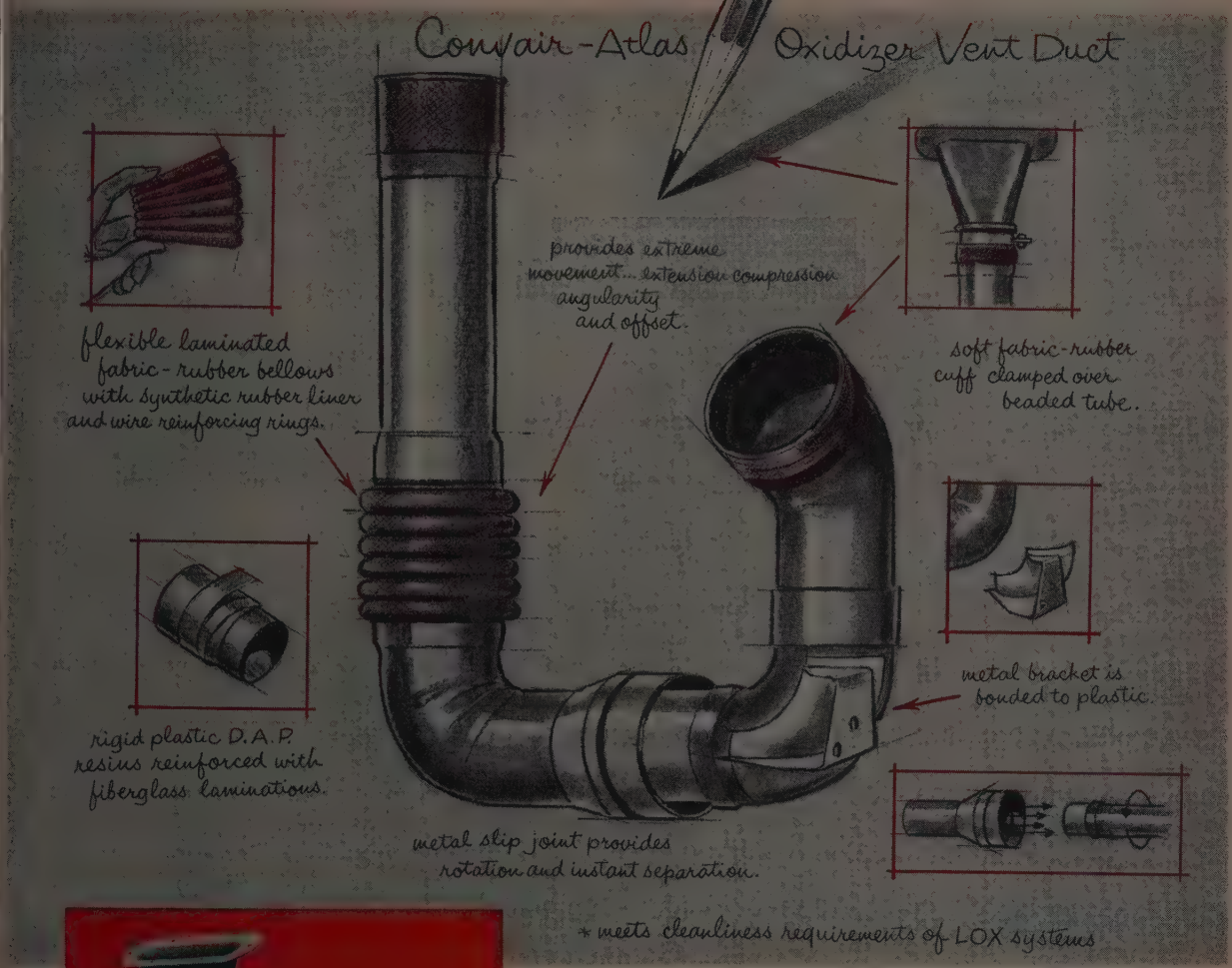
Write in No. 274 on Reader Service Card

ENVIRONMENTAL CHAMBERS—"Controlled Atmospheric Conditions" is a 28-page brochure that covers the environmental chamber line of **Webber Mfg. Co., Inc., Dept. S/A, P. O. Box 217, Indianapolis 6, Ind.** In addition to descriptions of a large number of chambers, the brochure includes charts of standard atmospheric properties, a relative humidity table, and altitude and temperature conversion charts.

Write in No. 275 on Reader Service Card

more on page 282

Design Notes on Ducting by Arrowhead


Convair-Atlas Oxidizer Vent Duct
provides extreme movement... extension compression angularity and offset.
flexible laminated fabric-rubber bellows with synthetic rubber liner and wire reinforcing rings.
soft fabric-rubber cuff clamped over beaded tube.
metal bracket is bonded to plastic.
rigid plastic D.A.P. resins reinforced with fiberglass laminations.
metal slip joint provides rotation and instant separation.
* meets cleanliness requirements of LOX systems

This Oxidizer Vent Duct serves as an excellent example of Arrowhead's engineering ability to design and produce in a combination of materials (metal, plastic and fabric-rubber) integral "no leak" units having abilities and features which could not be duplicated in any one or two of these materials.

The requirements of this application were for a flexible, lightweight duct assembly which would permit angularity, offset and rotational movements . . . withstand moderate temperatures...and provide a "leak free" slip joint allowing separation at 10 fps. speed.

For engineering consultation on such complex ducting problems contact Arrowhead's Field Service Representative in your area or write direct to the factory.

This complex rigid flexible Oxidizer Vent Duct is supplied to Convair (Astronautics) Division of General Dynamics Corp.

Arrowhead PRODUCTS

2300 Curry Street, Long Beach, California

Division of Federal-Mogul-Bower Bearings, Inc.

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RELIABILITY PLUS...

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Proven and tested to meet Mil Specs.
Lowest electrical noise levels.
Signal to noise ratio: 300 - 1.
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DATA PREVIEW

SCORING SYSTEMS — A 28-page brochure on missile scoring systems, which describes many major pilotless drones and optical scoring systems, has been issued by **Traid Corp., Dept. S/A, 17136 Ventura Blvd., Encino, Calif.** The brochure serves as a brief history of photographic scoring methods.

Write in No. 276 on Reader Service Card

SPRING WASHERS—A bulletin listing the dimensions of the many different sizes of washer dies on hand is designed to make it easy for designers to specify and for purchasing agents to order standard-size spring washers, by **Associated Spring Corp., Dept. S/A, Bristol, Conn.**

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MOTOR-GENERATOR — A high torque and low rotor inertia Size 8 servo motor-rate generator, the Model 8MG 420/410, has been described in Data Sheet 1402 by **Helipot Div., Beckman Industries, Inc., Dept. S/A, Newport Beach, Calif.** The four-page publication gives acceleration at stall as 110,000 rad/sec^2, said to be five times greater than competitive models.

Write in No. 278 on Reader Service Card

EXPLOSIVE ACTUATOR—Extensive descriptions of explosive actuated devices, such as switches and drivers, are contained in a data file prepared by **Armament Div., Universal Match Corp., Dept. S/A, P. O. Box 5841, St. Louis, Mo.** Other components covered include flare ejector systems and pyrotechnic test equipment.

Write in No. 279 on Reader Service Card

VALVES—The Series T (seat seal) and N (needle) valves, which have wide application for the missile industry, laboratories and pilot plants are described in Bulletins 3500-TR-1 and 3500-NR-1, respectively, by **Grove Valve and Regulator Co., Dept. S/A, 6509 Hollis St., Oakland 8, Calif.** The Series N has a maximum operating pressure of 6000 psi, and the T, 3000 psi, and both models have a standard operating temperature range of —30 to +150 deg. F.

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BEARINGS—An announcement and a specification sheet (Bulletin 58-2) for aircraft sealed track-roller bearings have been issued by **Smith Bearing Co., Dept. S/A, P.O. Box 1119, Trenton, N. J.** The bearings are made with dimensions to NAS502 and NAS503 Series, except for the width of the outer race.

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more on page 284

NEW

Sea Water Depth
PRESSURE
TRANSDUCERS

Sonar Submarine Torpedo Applications

- Input: sea water pressure
- Output: volts, a-c or d-c
- Hermetically sealed case
- Patented angle-wipe potentiometer
- 1000-hour service life

Ranges: 0-50 to 0-7500 feet

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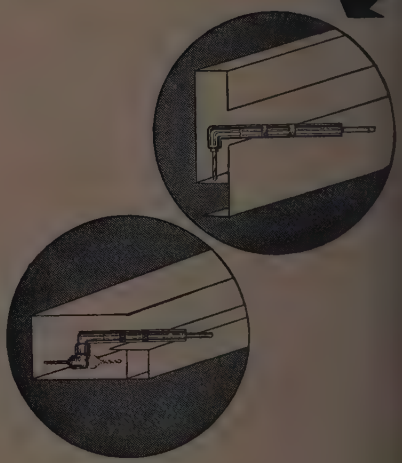

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DIVISIONS AND SUBSIDIARIES OF TELECOMPUTING CORPORATION
ENGINEERING SERVICES Specialists in rapid, accurate reduction and evaluation of military and commercial data. Currently handling data reduction for many missile firms at Holloman Air Force Base.
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The steps by which man approaches the Space Age consist, in major part, of advances in control technology.
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TELECOMPUTING CORPORATION
915 North Citrus Ave., Los Angeles 38, California

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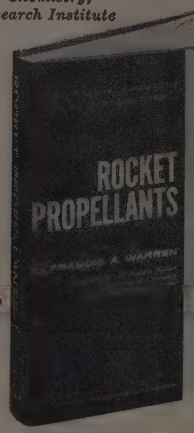
Just Published!
Includes chemical, manufacturing and performance details...

ROCKET PROPELLANTS

by FRANCIS A. WARREN
Manager, Special Projects Section, Department of Chemistry, Southwest Research Institute



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DATA PREVIEW

R-F FILTERS—R-f filters suitable for interference suppression in the VHF, UHF and microwave frequencies are described in an eight-page catalog by **Microphase Corp., Dept. S/A, Box 1166, Greenwich, Conn.** The catalog shows representative types and performance characteristics of various high-pass, low-pass, band-pass, diplexing and multiplexing filter networks, and preselectors.

Write in No. 282 on Reader Service Card

SWITCH—Data Sheet 148, describing what is said to be the world's smallest precision snap-action switch, is available from **Micro Switch Div., Minneapolis-Honeywell Regulator Co., Dept. S/A, Freeport, Ill.** 1SX1-T weighs 1/28 oz, measures .2x.35x.5 in. on the case and has characteristics the equivalent of switches twice the size.

Write in No. 283 on Reader Service Card

ELECTRIC PARTS—A new catalog featuring 13 specialized valves, solenoids and switches, is available from **Koontz Wagner Electric Co., Dept. S/A, 516 No. Michigan St., South Bend, Ind.** Components are marked by compactness, low current drain and reliability under difficult environmental conditions.

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METAL FINISHING—A new 24-page, four-color catalog on precision metal finishing by mechanical barrel-finishing methods is available from **Roto-Finish Co., Dept. S/A, Kalamazoo, Mich.** Included are illustrations and descriptions of equipment by model number, dimensions, capacities and accessories.

Write in No. 285 on Reader Service Card

MAGNETIC RELAY—Six pages of comprehensive information have been compiled in "The Magnetic Toggle Relay, 'MTR'" by **American Monarch Corp., Dept. S/A, 2801 37th Ave. N.E., Minneapolis 18, Minn.** Differences between the MTR and a conventional relay, as well as operational information, are included, and a four-page brochure covers applications and specifications.

Write in No. 286 on Reader Service Card

LINEARITY TESTER—A brochure describing their new Linearity Tester, Model 10, is available from **Spectrol, Electronics Div, Carrier Corp., Dept. S/A, 1704 So. Del Mar Ave., San Gabriel, Calif.** The model "10" is designed for fast, continuous readings of all types of potentiometer linearity.

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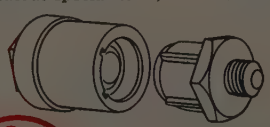
more on page 288

ON MARK COUPLINGS

NEW ON MARK QUICK DISCONNECT HYDRAULIC COUPLING...

Rated at 4000 P.S.I.

Designed for demanding hydraulic systems, ON MARK's new 5-5012 series couplings meet and exceed Mil-C-25427 . . . with a rating of 4000 P.S.I. For applications where the severe impulse requirements of Mil-C-25427 are not required, this coupling may be used with operating pressures up to 6000 P.S.I. The unique locking device, an integral part of the coupling, gives a full 360° grip on the mating part for maximum locking power. It will withstand extremely high pressure and shock loads, yet can be coupled or uncoupled without special tools, with no leakage. Available now in sizes from ¼" up.



SPECIAL SAFETY FEATURE
Basic coupling can be fitted with indexed "keys," as illustrated, to prevent mismatching different fluid lines.

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advertisement

SPECIAL REPORTS ON FINISHING NON-FERROUS METALS

NUMBER III—Lustrous, Corrosion-Resistant Finishing with Chemical Polishing Iridite

WHAT IS IRIDITE®?

Briefly, Iridite is the tradename for a specialized line of chromate conversion finishes. They are generally applied by dip, some by brush or spray, at or near room temperature, with automatic equipment or manual finishing facilities. During application, a chemical reaction occurs that produces a thin (.00002" max.) gel-like, complex chromate film of a non-porous nature on the surface of the metal. This film is an integral part of the metal itself, thus cannot flake, chip or peel. No special equipment, exhaust systems or specially trained personnel are required.

Chromate conversion coatings are widely accepted throughout industry as an economical means of providing corrosion protection, a good base for paint and decorative finishes for non-ferrous metals. Certain of these coatings also possess chemical polishing abilities that have luster-producing, as well as corrosion-inhibiting, effects on zinc and cadmium plate, zinc die castings and copper alloys. However, continued developments in this field have been so rapid that many manufacturers may not be completely aware of the breadth of application of this type of finish. Hence, this discussion of the many ways in which this chemical polishing characteristic can be used in final finishing or pre-plating treatments to produce a lustrous appearance with distinct display and sales appeal and appreciable savings in cost. Report I on decorative, corrosion-resistant finishes and Report II on paint base corrosion-resistant finishes are available on request.

The degree of luster possible on a surface is a function of the degree to which the surface can be smoothed. Leveling to provide a smooth surface can be achieved by mechanical or chemical means, or a combination of these, depending upon the luster desired and the original condition of the metal. Chemical polishing effectively imparts luster otherwise difficult and costly to obtain. For this reason, it is often used to supplement or entirely replace mechanical polishing, depending upon the application and the original condition of the metal. Chemical polishing has the additional advantage of providing overall treatment of the submerged part. It reaches into even the deepest corners and recesses that are otherwise inaccessible. Certain of the Iridites are specifically designed to perform this chemical polishing operation. Also, they provide corrosion protection as do all Iridites, thus may be used as a final finish or a pre-plating polish.

If Iridite is to be used as a final finish, in contrast to pre-plating treatment, the chromate conversion coating generated is allowed to remain, providing good corrosion resistance. Color inherent in these Iridite films ranges from a yellow cast to yellow iridescent. These coatings may be used without further treatment where this color is acceptable and good corrosion resistance is desired. Further, these basic coatings can be tinted by dyeing. Among the dye tints available are shades of red, yellow, blue and green. If desirable, the basic coatings can also be modified by a bleach dip leaving a clear bright or blue iridescent finish. In all cases bleaching reduces corrosion resistance.

As examples of this type of final finishing, Iridites #4-73 and #4-75 (Cast-Zinc-Brite) make possible for the first time, lustrous chemical polishing of the as-cast surface of zinc die castings. Thus, in many cases, sizeable savings in finishing cost are realized by elimination of plating costs. This economical method can be used on tools, appliance parts, toy pistols, locks and many other small castings. Another example is the treatment of copper and brass parts, such as welding tips, to eliminate buffing and provide additional corrosion resistance. In many cases, handling costs are reduced appreciably by replacing piece-part handling with bulk processing. Still another example of the use of this chemical polishing and protective quality of Iridite is a simple system of zinc plate, Iridite and clear lacquer instead of more costly electroplated finishes. Typical of this type of lustrous finish are builders hardware and wire goods.

As a pre-plating treatment, in contrast to final finishes, Iridite can be used to chemically polish zinc die castings or copper prior to plating. In such cases, Iridite should be applied as an in-process step, so that the protective film is removed before the plating cycle. The savings in handling, material and labor costs are obvious. This process has made it practical to plate chrome directly over copper on steel, conserving nickel, yet producing a lustrous chrome finish. Used after stripping faulty plate in reprocessing zinc die castings, Iridite restores luster to the casting, thus making possible replating without blistering.

Other Iridite finishes are available to produce maximum corrosion resistance, a wide variety of decorative finishes and excellent bases for paint on all commercial forms of the more commonly used non-ferrous metals. As a final finish, appearance ranges from clear bright to olive drab and brown and many films can be bleached or dyed. As a paint base Iridite provides excellent initial and retentive paint adhesion and a self-healing property which protects bare metal if exposed by scratching. Iridites have low electrical resistance. Some can be soldered and welded. The Iridite film itself does not affect the dimensional stability of close tolerance parts.

Iridites are widely approved under both Armed Services and industrial specifications because of their top performance, low cost and savings of materials and equipment.

You can see then, that with the many factors to be considered, selection of the Iridite best suited to your product demands the services of a specialist. That's why Allied maintains a staff of competent Field Engineers—to help you select the Iridite to make your installation most efficient in improving the quality of your product. You'll find your Allied Field Engineer listed under "Plating Supplies" in your classified telephone book. Or, write direct and tell us your problem. Complete literature and data, as well as sample part processing, is available. Allied Research Products, Inc., 4004-06 East Monument Street, Baltimore 5, Maryland.

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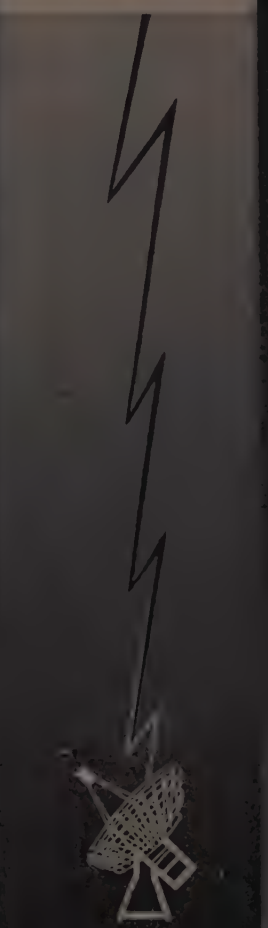

FROM THE SILENT VASTNESS . . . a voice

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Providing a voice that will continue to speak — no matter how adverse the conditions — is but one of Radiation's jobs in the Telemetry, Data Acquisition, Radar, Automatic Checkout, Antennas, and associated fields.

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IMPORTANT CAREER OPPORTUNITIES NOW OPEN. CONFIDENTIAL INQUIRIES INVITED.

Radiation's newly-improved 33-ounce FM TELEMETRY TRANSMITTER (Model 3115) has been proved successful in REDSTONE and JUPITER firings — and in many other missile, rocket-sled, and satellite programs.

- Completely miniaturized
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- Frequency range 215-260 mc.
- Will support your most critical telemetry application.

Certified tests have proved that this reliable, ruggedized unit is capable of operating under unusually extreme environmental conditions.

For complete information, write to RADIATION, INC. and ask for Bulletin RAD B-162.

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Fansteel Announces the First Space-Age Breakthrough in the Fabrication of Tungsten!

Tungsten! *By Deep Drawing!*

Tungsten! *By Spinning!*

Once again, Fansteel has unlocked the door to unlimited new uses for a valuable metal! Now we have ways to fabricate tungsten into involved shapes heretofore impossible . . . and through such economical processes as spinning, deep drawing, hot extrusion and forging!

Now . . . tungsten—with its melting point of 6152°F., highest of all metals, its terrific strength at high temperatures, its outstanding density of .697 lbs./cu. in.—can be exploited to the fullest. Great advances can now be made in the fields of missiles, nucleonics, aviation, medicine . . . even consumer products. Fansteel has broken through to the secret of fabricating tungsten . . . its potential is now unlimited.

Imagine rocket nozzles with tungsten's fabulous heat/strength properties. Or a tungsten-encased atomic power plant weighing just five pounds. Picture a pure tungsten gyroscope rotor, almost 25% smaller than is now possible, yet retaining complete functional reliability due to its low coefficient of expansion.

Tungsten electronic tube components, tiny wristwatch flywheels and thousands of other applications are now also feasible with Fansteel's tungsten fabrication know-how.

This revolutionary knowledge is so new that we can't supply bulletins, technical information, or other printed data. But our engineers will be glad to cooperate with your own designers and production people in adapting tungsten and these new fabricating techniques to your part or product. Just send print, part samples or cal' in the Fansteel representative.

FANSTEEL

HIGH TEMPERATURE METALS

RSV1

FANSTEEL METALLURGICAL CORPORATION, NORTH CHICAGO, ILLINOIS, U. S. A.

Write in No. 113 on Reader Service Card at start of Product Preview Section

WesCo has hundreds of Aircraft and Industrial solenoids

Look to **WesCo** engineers with your aircraft or industrial solenoid problem. Hundreds of proven designs available. **WesCo** will modify or furnish special designs to fit your specifications.

Here are some of the features available:
High temp units tested past 600°F. • Adjustable plunger travel • Plunger cavity pressure sealed • Push or pull types 12 to 115 volts • Miniature, medium and heavy duty types • 400 cycle AC units also available.

Remember, when you need a solenoid, think of **WesCo AC INDUSTRIAL SOLENOIDS**—full line. Write for brochure. **DC AIRCRAFT SOLENOIDS**—send specifications, or write for catalog.

The trademark on millions of solenoids since 1927

WesCo

WEST COAST ELECTRICAL MFG. CORP.

233 WEST 116TH PLACE • DIVISION 102
LOS ANGELES 61, CALIF. • PLymouth 5-1138

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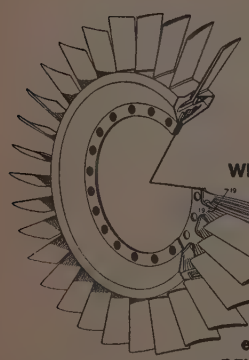
GAS TURBINE ROTORS

LIGHT IN WEIGHT!

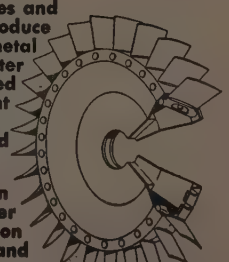
TO CLOSEST TOLERANCES!

LOW COST!



WE ELIMINATE COSTLY MACHINING!

Stalker's modern facilities and advanced techniques produce precision-formed sheet metal rotors — 50% to 75% lighter than more costly machined counterparts. Lighter weight rotors mean lighter weight engines — and greatly increased pay loads.



To customers with products requiring precision fabrication and high temperature brazing of stainless steel and super alloys, Stalker also offers complete testing and inspection facilities. U.S. Air Force certification for both brazing and heat treat.

Whatever your problem may be, our engineering, development and production facilities are at your disposal. Write, wire or phone for information.

THE STALKER CORPORATION ■ 905 WOODSIDE
ESSEXVILLE, MICHIGAN

Write in No. 155 on Reader Service Card at start of Product Preview Section

DATA PREVIEW

SOLID FILM LUBRICANT—A high load carrying solid film lubricant is given complete technical coverage in a four-page data sheet by **Electrofilm, Inc., Dept. S/A, P. O. Box 106, No. Hollywood, Calif.** Data on wear life versus load at various speeds, friction and physical properties, and fluid immersion tests are included.

Write in No. 288 on Reader Service Card

CONTROLLER—Technical Bulletin RF-587 issued by the **Aeronautical & Instrument Div., Robertshaw-Fulton Controls Co., Dept. S/A, 401 N. Manchester, Anaheim, Calif.**, gives details of a compact pneumatic-electronic control device, said to detect and control changes in media level with exceptional precision.

Write in No. 289 on Reader Service Card

AIRCRAFT STEELS — The 1958 Edition of its booklet on aircraft steels, which contains condensed information on aeronautical specifications, is available from **Joseph T. Ryerson & Son, Inc., Dept. S/A, Box 8000-A, Chicago 80, Ill.** The 72-page booklet also includes a list of aircraft quality alloy and stainless steels, and data on an unusual plan of quality control.

Write in No. 290 on Reader Service Card

PRESSURE SWITCH — The Series 700 is a one-oz, all-aluminum pressure switch suitable for missile application, according to Bulletin PS-7, issued by **Alloy Bellows, Inc., Dept. S/A, 18125 Roseland Rd., Cleveland 12, O.** Models of the piston-type spdt switch, which is rated for five amps at 240 V, cover a pressure range from 25 to 1000 psi, with a 3000-psi over pressure.

Write in No. 291 on Reader Service Card

TERMINALS—A new, 16-page catalog, pre-punched for looseleaf filing, describes the wide variety of electrical terminals and attaching machines available from **Kent Mfg. Corp., Dept. S/A, 188 Needham St., Newton, Mass.** The T&B catalog covers snap-on male and female-type terminals in both straight and flag varieties, as well as ring, spade and hook terminals.

Write in No. 292 on Reader Service Card

CIRCUIT BREAKERS — Complete information for the use of the current-limiting Cordon circuit breaker for short-circuit protection on low-voltage systems is given in a new comprehensive, 20-page bulletin, No. 5043-A, published by **I-T-E Circuit Breaker Co., Dept. S/A, Philadelphia, Pa.** A wide variety of applications are given.

Write in No. 293 on Reader Service Card

more on page 292

Pesco axial flow fans offer maximum performance and reliability

ELECTRONIC EQUIPMENT—Tiny Pesco "Mini-Spot" Fan with built-in motor weighs only 4 ounces. Miniature fan delivers 33 cfm for spot cooling of high-temperature tubes in aircraft and missile electronic units.

STARTING SYSTEMS—Pesco Fan rated at 850 cfm at 16″ w.g. is used for cabin ventilation and in jet engine starting systems for cooling motor-generator sets and oil.

HELICOPTERS—V-belt driven Pesco Fan cools engine oil on several makes of helicopters. Special Pesco design reduced weight by 23%.

GROUND SUPPORT SYSTEMS—This Pesco unit is used in condenser and evaporator fan applications in air conditioning systems for ground support of missiles and high-performance aircraft. Rating is 4260 cfm at 6.5″ w.g.

When you specify Pesco Axial Flow Fans (with built-in Pesco Electric Motors), you get maximum operational reliability plus the advantages of—

single fan-and-motor source—Pesco designs and manufactures both fans and motors. This permits close design coordination resulting in better matching of fan and motor characteristics, closer tolerances, savings in time and money, higher performance.

superior performance—use of most advanced aerodynamic principles assures unsurpassed total efficiency. Individual parts balancing provides quiet, vibrationless operation. Self-cooling motor is custom-built for application.

miniaturized design—self-contained package with built-in motor assures minimum envelope, provides more capacity for given weight or size. Fan can mount in duct to save space and power.

lower maintenance—simplified design makes maintenance easier, cheaper. Built-in motor is readily accessible, can be serviced without breaking electrical connections to housing exterior.

You can choose from over 40 standard designs of Pesco Axial Flow Fans: intermittent or continuous duty, ratings from 16 to 5000 cfm, wide pressure range. Or Pesco will custom-design a fan to meet your exact needs. All Pesco Fans conform to latest MIL specifications. For further information, write for Bulletin 5703.

PESCO PRODUCTS DIVISION
BORG-WARNER CORPORATION
24700 North Miles Road • Bedford, Ohio

PROJECT ENGINEERS:
Pesco can furnish completely engineered fans, designed for any known application, to meet tight project deadlines!

PESCO . . . engineering Pesco production *means progress in fans*

PESCO BW BORG-WARNER TRADEMARK

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Career Opportunities at NASA

NASA directs and implements the Nation's research efforts in aeronautics and the exploration of space for peaceful purposes and the benefit of all mankind. We offer unique opportunities in basic and applied research to scientists and engineers with degrees in the various disciplines.

Briefly described here are representative current NASA programs. Openings exist in all of these programs, at the facilities named.

SPACE TECHNOLOGY

Space vehicle development, including basic planning, development, contract coordination, and operational programming and planning for manned and unmanned satellites. Systems studies for auxiliary power supplies, air regenerative systems, instruments, guidance and communication equipment for space vehicles.

Space probes: Development and operation of vehicles, payload and instrumentation, programming and operation of flight, trajectory, communication systems, and ground support systems for near space and deep space probes.

Beltsville

SPACE MECHANICS

Experimental and analytical study of orbital mechanics including parameters of preliminary and refined orbits, ephemerides, lifetimes, equator crossings and perturbations.

Beltsville; Langley; Ames

PROPULSION AND PROPULSION SYSTEMS

Developmental studies of boosters, launchers, multi-stage engines, guidance and attitude control systems for space vehicles.

Basic research on the interrelationships between electrical, magnetic and thermodynamic energy, and application of such knowledge to space propulsion.

Magneto hydrodynamics: Research on plasma and ion accelerators for space propulsion and auxiliary power systems.

Research on reactors and reactor shielding for aeronautical and space propulsion systems.

Beltsville; Lewis

AERODYNAMICS AND FLUID MECHANICS

Investigation of the thermodynamics and transport properties of gases at high temperatures as encountered in entry into planetary atmosphere.

Research on performance, stability and control, automatic guidance, and navigation for subsonic, supersonic, and hypersonic aircraft.

Aerodynamic heating and satellite re-entry phenomena.

Langley; Ames; Lewis; High-Speed Flight Station

(Positions are filled in accordance with Aeronautical Research Announcement 61B)

INSTRUMENTATION AND COMMUNICATION

Research and development of new sensing devices and instrumentation techniques in electronics, optics, aerodynamics, mechanics, chemistry and atomic physics.

Systems studies and evaluation of control, guidance, navigation, and communication equipment for space vehicles and other high performance applications requiring rugged and compact design.

All Facilities

GEOPHYSICS, ASTRONOMY AND ASTROPHYSICS

Experimental programs and evaluation studies of astronomical and geophysical measurement and scientific equipment used in space vehicle payloads.

Studies of fields and particles in space, investigations of the composition of planetary atmospheres, and development of instrumentation and experimental techniques for these investigations.

Beltsville

STRUCTURES AND MATERIALS

Investigation of the characteristics of high temperature structures and materials. Study of fatigue, structural stability, and other problems of structural dynamics.

Solid State Physics: Study of the elementary physical processes involved in mechanical behavior of materials, such as fractures; the nature of the corrosion process; and physical-chemical relationships governing behavior of materials.

Langley; Ames; Lewis

MATHEMATICS

Application of advanced mathematical techniques to the solution of theoretical problems in aeronautical and space research, involving the use of large modern computing equipment.

All Facilities

RESEARCH FACILITY ENGINEERING

Translation of research specifications into complete experimental facilities, involving mechanical, electrical, structural, architectural and machine design, and construction engineering.

Langley; Ames; Lewis

Please address your inquiry concerning any of the programs listed here to the Personnel Director of the appropriate NASA research center:

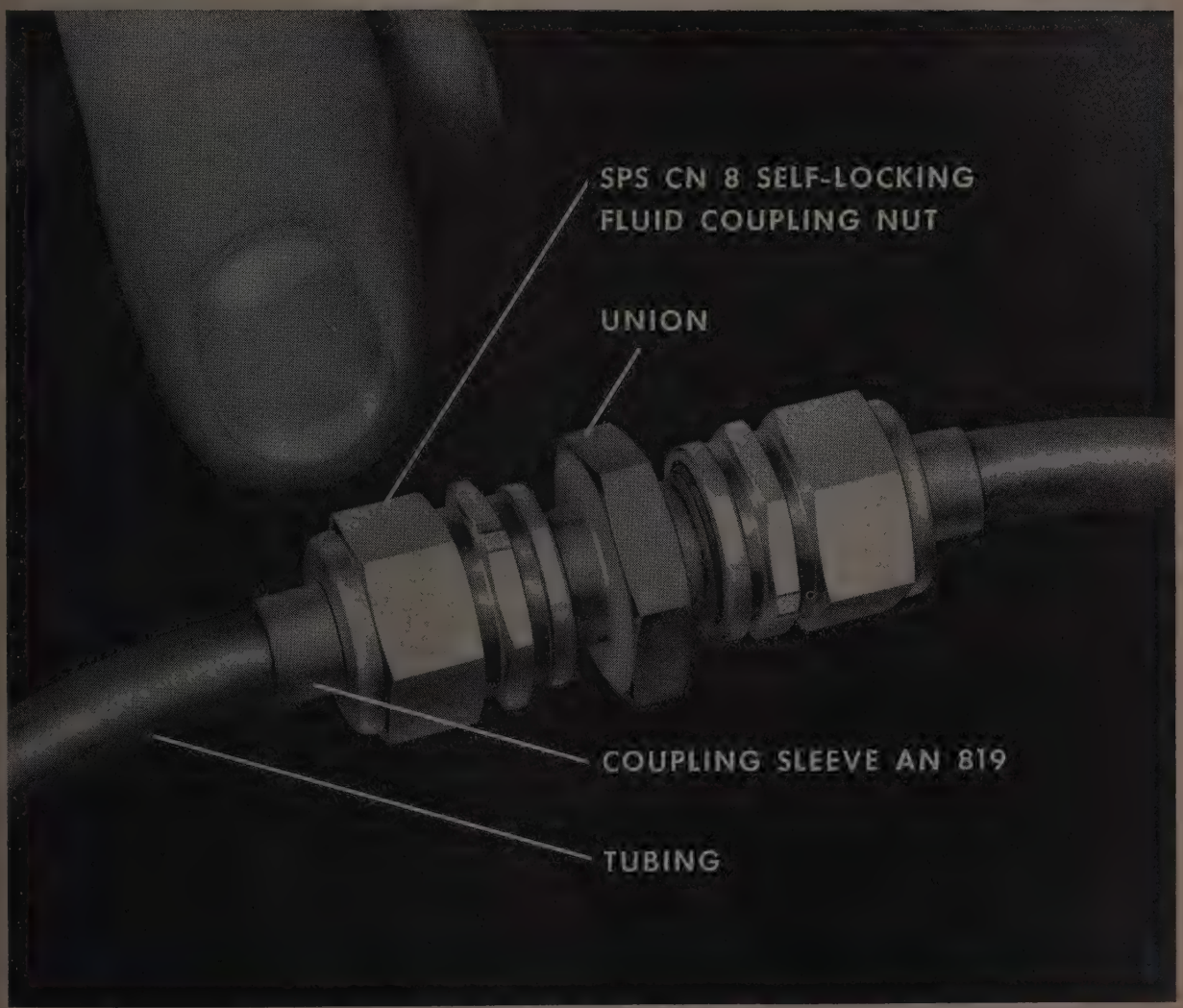
Langley Research Center, Hampton, Virginia
Ames Research Center, Mountain View, California
Lewis Research Center, Cleveland, Ohio
High-Speed Flight Station, Edwards, California
Beltsville Space Center, 4555 Overlook Ave., Washington, D. C.

NASA National Aeronautics and Space Administration

Check Employment Inquiry Form on Page 181

New from SPS Laboratories

CN 8...first self-locking coupling nut for fuel, hydraulic and oil lines



New free-starting, self-locking coupling nut insures vibration-proof tightness—and freedom from leaks caused by nut backoff—in fluid system line joints. And the self-contained locking action of this all-metal unit eliminates costly techniques in wiring to prevent loosening from vibration. Characteristics are given in Bulletin 2488. Write for a copy today. Aircraft/Missiles Division, STANDARD PRESSED STEEL CO., Jenkintown 54, Pa.

SPS **Jenkintown • Pennsylvania**

Standard Pressed Steel Co. • The Cleveland Cap Screw Co. • Columbia Steel Equipment Co. • National Machine Products Co. • Nutt-Shel Co. • SPS Western • Standco Canada, Ltd. • Unbrako Socket Screw Co., Ltd.

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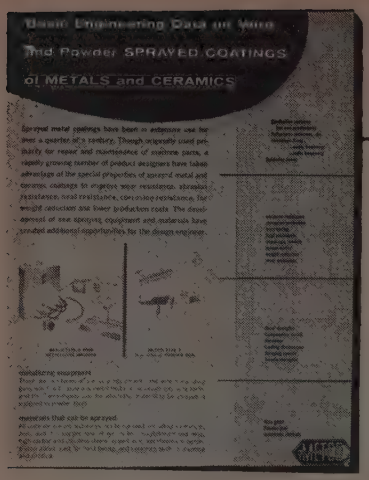


new engineering bulletin

Free data on sprayed coatings of metals and ceramics

Continuing developments in spraying equipment and materials, both metals and ceramics, are creating many opportunities for the design engineer to take advantage of the special properties of these coatings to improve wear resistance, abrasion resistance, heat resistance, corrosion resistance, for weight reduction and lowered production costs.

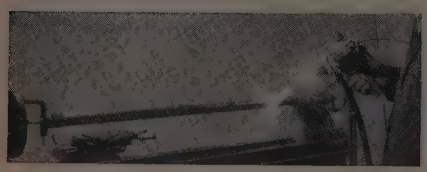
typical applications

Jet Engine Starter

Interior surfaces of exhaust-duct and combustion-chamber assemblies of jet starter engines are being protected by coating with alumina. This provides a thermal barrier to prevent creep and deformity of the chamber during the 1500° F. operating cycle.

Rocket ring mounts

030" thick coating of alumina protects laminated plastic ring mount against rocket blast during firing cycle; more than meets specifications.



Torque tube

Aluminum torque tubes, used in control of aircraft trim tabs are hard-surfaced with stainless steel over molybdenum at press-fit bearing sections.

free bulletin

Eight-page Engineering Data Bulletin No. 136 provides engineering data on sprayed coatings of metals and ceramics; illustrates and details typical application and provides a complete round-up of latest developments in equipment and materials as well as their characteristics. Use the handy coupon below.

Metallizing Engineering Co., Inc.
1133 Prospect Ave., Westbury, N. Y.

Please send me free Bulletin 136.

Name Title

Company

Address

City Zone State

Write in No. 159 on Reader Service Card at start of Product Preview Section

DATA PREVIEW

FACILITIES—Facilities for aeronautical and astronautic products are described in a 16-page publication by **The Firewel Co., Inc., Dept. S/A, 3685 Broadway, Buffalo 25, N.Y.** The brochure includes a review of company achievement in oxygen breathing equipment.

Write in No. 294 on Reader Service Card

COUNTER—The CV magnetic predetermining counter, which has a wide range of airborne instrumentation, programing, count down, flow metering and other applications, has been described in a data sheet by **Abrams Instrument Corp., Dept. S/A, 606 E. Shiawassee St., Lansing, Mich.** The CV counts down any number manually set from one to 899.

Write in No. 295 on Reader Service Card

EXPANSION JOINTS — Complete information for rating expansion joints subjected to axial or lateral movement is among the data included in an 80-page catalog on S-R expansion joints, available from **Badger Mfg. Co., Dept. S/A, 230 Bent St., Cambridge, Mass.** Formulae and tables are included to aid in calculations of the forces and bending movements developed in the connected piping or equipment.

Write in No. 296 on Reader Service Card

VIBRATION PICKUPS—Information of three new vibration pickups, particularly suited for in-flight monitoring of jet engines and other constantly vibrating equipment, appears in CEC Bulletin 1596, available from **Consolidated Electrodynamics Corp., Dept. S/A, 300 No. Sierra Madre Villa, Pasadena, Calif.**

Write in No. 297 on Reader Service Card

POWER SUPPLY—Basic information on a 28-V. 25- to 35-amp, unregulated transformer-rectifier airborne power supply is furnished in Bulletin GEC-1501 by **General Electric Co., Dept. S/A, Schenectady 5, N.Y.** The two-page publication includes the electrical and mechanical characteristics of the eight-lb, convection-cooled unit.

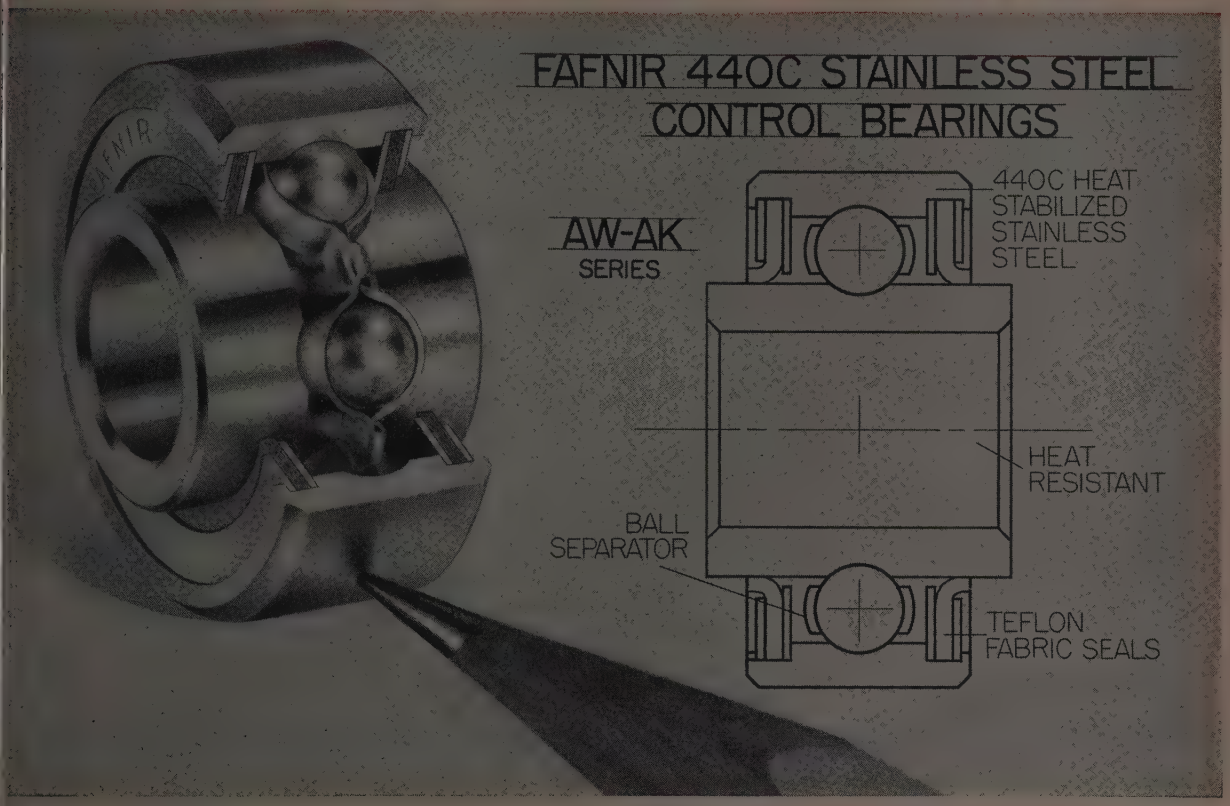
Write in No. 298 on Reader Service Card

ACTUATORS—WF 1394, a data sheet describing low-leakage, solenoid-controlled actuator packages for hydraulic and pneumatic applications, has been issued by **Waldorf Instrument Co., Dept. S/A, Huntington Station, N.Y.** The units, in use in missile applications, are available for pressures to 3000 psi and for continuous duty temperatures to +500 deg F.

Write in No. 299 on Reader Service Card

more on page 294

NEW FOR HIGH-SPEED AIRCRAFT



Designed for low torque, high temperature operation... the new AW-AK heat-stabilized, sealed ball bearing series

To meet the need for ball bearings designed specifically for high-speed aircraft "sensitive" control applications, Fafnir announces a new, high-temperature, low-torque series fabricated entirely of stainless steel.

Designated the AW-AK Series, these new, medium capacity ball bearings are heat-stabilized, and lubricated with heat-resistant oil. Teflon fabric seals, capable of withstanding temperatures in the 550° range, are available. These seals keep seal drag to a minimum.

The bearings are equipped with stainless steel ball separators that insure extremely low torque. Bearing widths to close tolerances permit ready mounting in standard brackets. This series is especially suitable for application in the critical area forward of the power boost system, where low torque, minimum play, and high temperature operation are required.

Send for new engineering data sheet. Write The Fafnir Bearing Company, New Britain, Connecticut.

AW-AK SERIES DIMENSIONS AND LOAD RATINGS

BEARING NUMBER	B	D	W	H	A	E	C	BALLS		RADIAL LIMIT LOAD RATING LBS.	WEIGHT POUNDS (APPROX.)
	BORE	OUTSIDE DIAMETER	WIDTH INNER RING	WIDTH OUTER RING	SHOULDER DIAMETER INNER RING (APPROX.)	CORNER CHAMFER x 45° INNER RING BORE	CORNER CHAMFER x 45° OUTER RING O.D.	NO.	SIZE		
	+.0000 −.0005	+.0000 −.0005	+.0000 −.0025	+.000 −.005		+.015 −.000	+.015 −.000				
AW3AK	.1900	.6250	.406	.312	.317	.005	.016	6	1/8	750	.018
AW4AK	.2500	.7500	.438	.312	.415	.005	.016	7	1/8	880	.028
AW5AK	.3125	.8125	.469	.344	.462	.015	.016	7	5/32	1370	.033
*AW6AK	.3750	.8750	.469	.344	.520	.015	.016	7	5/32	1370	.034
*AW8AK	.5000	1.1250	.562	.438	.681	.015	.016	8	3/16	2250	.075
*AW10AK	.6250	1.3750	.594	.469	.848	.015	.032	8	1/2	3060	.119
*AW12AK	.7500	1.6250	.656	.531	1.052	.015	.032	8	1/4	4000	.189
*AW16AK	1.0000	2.0000	.688	.562	1.334	.015	.032	10	1/4	5000	.296
*AW20AK	1.2500	2.2500	.688	.562	1.615	.015	.032	12	1/4	6000	.355

* Not in production. Will be produced as requirements justify tooling.

FAFNIR
AIRCRAFT BEARINGS
FIRST AT THE TURNING POINTS OF AIRCRAFT DESIGN

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Trainer to X-15... and beyond

ALL fly with Fluoroflex®-T hose of Teflon®

AVRO
BOEING
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CHANCE VOUGHT
CONVAIR
DOUGLAS
GRUMMAN
LOCKHEED
McDONNELL
MARTIN
NORTHROP
NORTH AMERICAN
REPUBLIC

There's performance to spare in Fluoroflex-T hose assemblies. High temperatures? They serve to 500°F . . . and beyond, in some cases. High pressures? They've passed rigid tests even for 4000 psi systems. Long impulse life? They're tested to 250,000 cycles . . . more than *double* industry standards. Optimum reliability? They've been flying for more than five years in jet and reciprocating aircraft.

That's why Fluoroflex-T hose assemblies are favored for fuel, lubrication, hydraulic, escape and fire control systems in so many existing aircraft. And that's why they're being specified for so many aircraft now being designed – they have performance to spare.

For data, write Department 230
RESISTOFLEX CORPORATION, Roseland, N. J.
Other Plants: Burbank, California; Dallas, Texas.

®Fluoroflex is a Resistoflex trademark, reg., U.S. pat. off.
®Teflon is DuPont's trademark for TFE fluorocarbon resins.

RESISTOFLEX

Write in No. 161 on Reader Service Card at start of Product Preview Section

TRANSISTOR CIRCUITS—A 60-page booklet on transistor theory and circuits has been published by **Sylvania Electric Products, Inc., Dept. S/A, 1100 Main St., Buffalo 9, N. Y.** The publication contains 36 circuit descriptions, with accompanying schematic diagrams and parts lists, and information on how to build a variety of transistorized components. Title: "Performance Tested Transistor Circuits." Price: $0.35.

Write in No. 300 on Reader Service Card

FACILITIES—An eight-page brochure describing its capabilities and facilities for work in the rocket and missile industry and related fields has been prepared by **Astrodyne, Inc., Dept. S/A, P. O. Box 548, McGregor, Texas.** Both manufacturing and research and development facilities are discussed..

Write in No. 301 on Reader Service Card

SERVO MOTOR—Data Sheet 1301 offers four pages of information on the Model 15 IM 461, Size 15, inertia-damped servo motor, developed by **Helipot Div., Beckman Instruments, Inc., Dept. S/A, Newport Beach, Calif.** A dimensional drawing, schematic and torque-speed curve have been included, along with other data, for the 115-V, 400-cycle unit.

Write in No. 302 on Reader Service Card

FLAME CUTTING—The features of the No. 56 Oxygraph flame cutting machine are covered in the 16-page Catalog 804B, availale from **Air Reduction Sales Co., Dept. S/A, 150 E. 42nd St., New York 17, N.Y.** The multiple-torch model's gas distribution system and accessories, including the electronic tracer, are discussed.

Write in No. 303 on Reader Service Card

NUMERICAL CONTROL—Bulletin GET-2676, 14 pages, describes functions of numerical positioning control, and provides data accumulated from particular applications on a variety of machines using this type of control. This publication is available from **General Electric Co., Dept. S/A, Schenectady 5, N. Y.**

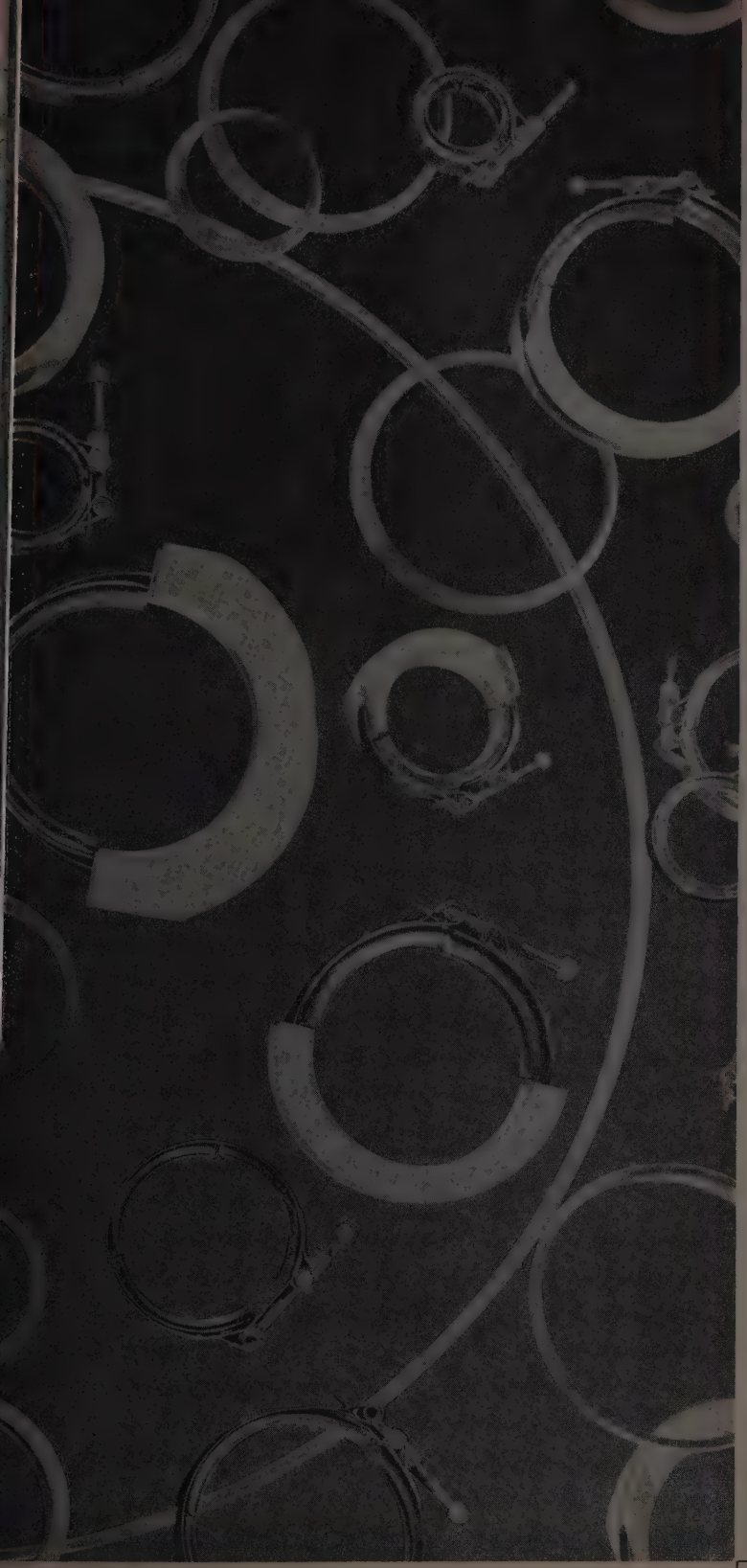
Write in No. 304 on Reader Service Card

FILLER CAPS—A bulletin (Form 435) on filler caps and servicing caps applicable to fuel, oil, water-alcohol and hydraulic reservoirs has been issued by **Gabb Special Products, Inc., Dept. S/A, Windsor Locks, Conn.** The brochure offers dimensions, typical uses, and military and commercial applications.

Write in No. 305 on Reader Service Card

more on page 296

Write in No. 162 on Reader Service Card ➔



reliable couplings unlimited

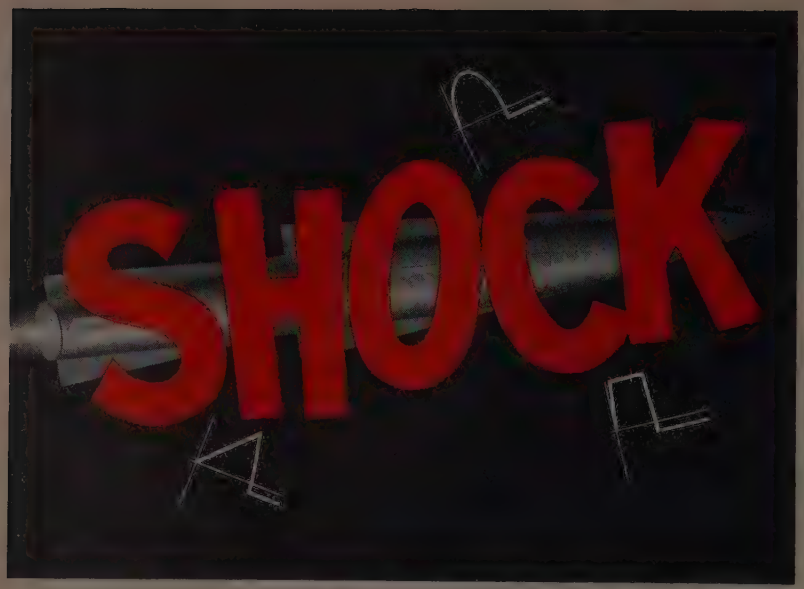
Thousands of Janitrol couplings for high-temperature high-pressure ductwork are proving their reliability on advanced aircraft and missiles: DC-8, 720, 880, 707, KC 135, CF 105 (Mark I and II), F4H, F8U3, P6M, S-55, HR-251, H19D4, H34A, H37A, Regulus II and the Green Quail.

Couplings are furnished in titanium as well as stainless steel; sizes range from 1″ to 36″ diameter. Janitrol coupling reliability is firmly based on a unique combination of research, design, testing and manufacturing facilities capable to handle complete systems including heat exchangers, coolers, and controls.

Call the Janitrol representative near you for help early in the design stage.

Janitrol Aircraft Division
Surface Combustion Corporation
4200 Surface Road
Columbus 4, Ohio

JANITROL®



Only HYGE can produce and repeat so many different kinds of shock

60-second test simulates exact service conditions, records shock waves on oscilloscope for instant reference or photography.

What shock situation would you like to set up? Shock loads to missile launcher? Re-entry—to atmosphere, land or water? Rocket fuel handling? Parachute landing? Underwater or underground explosion? You can simulate them all with HYGE . . . and repeat each one exactly . . . for only pennies per test. And as new test requirements develop, an inexpensive metering pin adapts HYGE to meet them. You have a permanent source of stored energy—variable, to meet your needs, up to 40,000 lbs. thrust—with versatility for a wider range of shock wave patterns than with any other equipment. If shock is a factor in the success of your project, you'll want to know more about HYGE.

Write for Bulletin 5-70-A . . . theory, application and specification data on HYGE Shock Testers.

Consolidated Electrodynamics

Rochester Division, Rochester 3, N.Y.

SALES AND SERVICE OFFICES IN PRINCIPAL CITIES

Write in No. 163 on Reader Service Card at start of Product Preview Section

DATA PREVIEW

MICROSCOPY — "Accessories for Microscopy" is the title of a brochure and catalog supplement issued by **Ernest F. Fullman, Inc., Dept. S/A, P.O. Box 444, Schenectady 1, N.Y.** Devices covered include electron microscopy grids, high-intensity viewing screens, precious metal wire, and molybdenum apertures.

Write in No. 306 on Reader Service Card

CASTING ALLOY—A general information brochure and design data on Tens-50, a high-strength aluminum casting alloy that can be used for sand or permanent molds, have been prepared by **Navan Products, Inc., Dept. S/A, 1318 Second St., Santa Monica, Calif.** The alloy can be used in critically loaded aircraft and missile structures.

Write in No. 307 on Reader Service Card

VIBRATION ISOLATION—A thorough discussion of pneumatic vibration isolation systems for delicate control systems such as are used in missiles is presented in the 24-page Catalog 103 by **Walter Kidde & Co., Inc., Dept. S/A, Belleville 9, N. J.** Design considerations, system and operational requirements, and environmental conditions are among the factors discussed in the illustrated booklet.

Write in No. 308 on Reader Service Card

BOLTS—How to determine the required torque for proper tightening of bolts according to specific requirements, is a universal problem according to a special report released by **Skidmore - Wilhelm Mfg. Co., Dept. S/A, 442 South Green Rd., So. Euclid, Ohio,** which discusses the problem covering torque-tension data and application of data.

Write in No. 309 on Reader Service Card

VACUUM-JACKETED LINES—High Vacuum-Jacketed transfer lines, said to cut boil-off losses of liquid fuels, and the related equipment for rockets and missiles are described in CEC Bulletin 4-80, available from **Rochester Div., Consolidated Electrodynamics Corp., Dept. S/A, 1775 Mt. Read Blvd., Rochester, N.Y.**

Write in No. 310 on Reader Service Card

BLIND RIVET—The Series 6900 and 7900 drive-pin blind rivets are the subject of two test reports issued by **Deutsch Fastener Corp., Dept. S/A, P.O. Box 61072, Los Angeles 61, Calif.** Bulletin 6 is concerned with the rivets' shear and tension values, and Bulletin 7 covers static and repeated load testing.

Write in No. 311 on Reader Service Card

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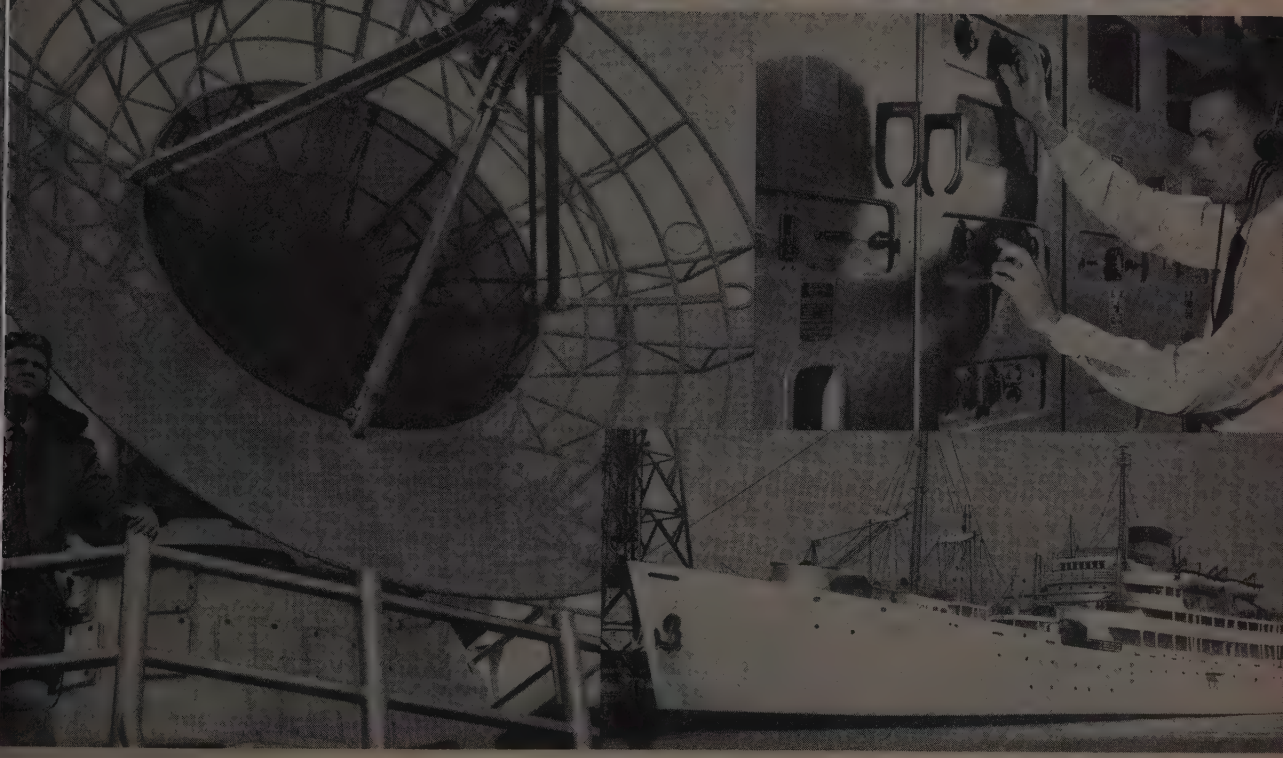
MISSILE TRACKING

SEA-LAB



This huge antenna is part of an electronic and optical system that RCA installed and is operating on the S.S. American Mariner. The purpose of the equipment, for which the ship has been refitted, is to provide the most precise data yet obtained at sea on missile flights over a range extending from Cape Canaveral, Fla., to the area of Ascension Island. The project is sponsored jointly by the Advanced Research Projects Agency, Department of Defense and the Army Ordnance Command. A scientific staff—most of them RCA personnel—will operate the equipment and report on missile performance from descent from space to final plunge, the data to be shared by all branches of the armed services.

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CAMDEN, N. J.

EXPANDED RESEARCH

to advance new concepts of SPACE FLIGHT

Expanded Research programs to meet the most complex technological requirements of the Space Age are only one of the far-reaching objectives of the new multi-million-dollar Lockheed Research Center, near Los Angeles. Destined to become one of the nation's major research installations, its programs are broad in scope and designed to investigate new frontiers of space flight.

A primary consideration in planning the new Research Center was to provide environment for scientific freedom and ideal research conditions —using the most advanced equipment available. This modern, integrated research facility will touch almost every aspect of aviation and transportation—leading toward exploration into completely new or relatively undeveloped fields of science and industry.

On completion, most of Lockheed's California Division's research facilities will be located in this single area. The Center will provide complete research facilities in all fields related to both atmospheric and space flight—including propulsion, physiology, aerodynamics and space dynamics; advanced electronics in microwave propagation and infrared; acoustics; mechanical and chemical engineering and plasma/magneto-hydrodynamics; thermal electricity; optics; data communications; test and servo-mechanisms.

The first phase of the advanced research building program has already begun—with initial construction of a $5,000,000 supersonic wind tunnel and high-altitude environmental test facilities.

Scientists and engineers of high caliber are invited to take advantage of outstanding career opportunities in this new Lockheed Research Center. Openings now exist for thoroughly qualified personnel in: Electronics; aero and thermo dynamics; propulsion; servo-mechanisms; materials and processes; structures and stress; operations research; research in optics, infrared, acoustics, magnetohydrodynamics, instrumentation, mechanics and hydraulics; mathematics and in all phases of design.

Write today to: Mr. E. W. Des Lauriers, Manager Professional Placement Staff, Dept. 1904, 1708 Empire Avenue, Burbank, California.

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CALIFORNIA DIVISION

BURBANK, CALIFORNIA

DATA PREVIEW

GEAR CASE—"Tedeco Accessories for Aircraft Gear Cases," a new 20-page catalog featuring full scale drawings of every size of every product facilitating tracing by designers or draftsmen, is available from **Technical Development Co., Dept. S/A, Glenolden, Pa.** Complete dimensions and specifications are given for this line of accessories.

Write in No. 312 on Reader Service Card

SWITCHES — "Custom Designed Switches for Aircraft and Missile Applications" is the title of a new six-page bulletin released by **Airtron, Inc., Dept. S/A, 1096 W. Elizabeth Ave., Linden, N. J.** Ten representative switches, including heavy-duty, multi-contact and compact, multi-circuit designs for power transfer in missiles, have been described and illustrated.

Write in No. 313 on Reader Service Card

POWER SUPPLY—Lists of electrical and mechanical characteristics and detailed outline drawings are used in Bulletin GEC-1494 to describe the key features of a 16.5 lb, fan-cooled airborne power supply made by **General Electric Co., Dept. S/A, Schenectady 5, N.Y.** The device is a 28-V, 200-amp, unregulated transformer-rectifier supply.

Write in No. 314 on Reader Service Card

MACHINE TOOL—What is said to be the first machine tool on which numerical control is offered as standard equipment is described in a 12-page catalog available from **Marac Machinery Corp., Dept. S/A, 45 S. Broadway, Yonkers, N. Y.** The Schwartzkopff KBF2 boring and milling machine has all operations controlled by numerical dials or punched cards.

Write in No. 315 on Reader Service Card

TOOL CONTROLS — A 24-page, two-color bulletin on machine tool controls is published by **True-Trace Sales Corp., Dept. S/A, 9830 E. Rush St., El Monte 43, Calif.** The bulletin describes accessory units and discusses profile, contour, and straight line machine tool controls as a part of modern metal-cutting technology, as a means of contouring newer and harder metals.

Write in No. 316 on Reader Service Card

ALLOY POWDER—Technical data on Alloy Powder HS 6460, which was developed for use in higher stressed parts produced with existing operating equipment, are contained in a 14-page booklet issued by **Republic Steel Corp., Dept. S/A, 1441 Republic Bldg., Cleveland 1, O.** Properties, specifications, and heat-treating recommendations are included.

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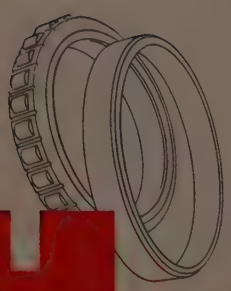
THE WORLD'S MOST MODERN AIRCRAFT ENGINES ARE FLYING HIGH WITH HYATT HY-ROLLS



HYATT HY-ROLL BEARINGS play an important part in the most critical applications of today's modern aircraft. Whether you manufacture jets or 'copters . . . turn to HYATT for assured bearing dependability. Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey.

Another GM GENERAL MOTORS contribution to aviation progress

HYATT HY-ROLL BEARINGS FOR AIRCRAFT INDUSTRY

Write in No. 166 on Reader Service Card at start of Product Preview Section

letters to the editor

Program for changing to metric

Hurray for you! I have long awaited someone with guts enough to attempt to overcome the terrific inertia and the resistance to change the present situation—which is intolerable, and which will only get worse if allowed to continue.

It is my understanding that several previous half-hearted and unsupported attempts by logical, and intelligent, people only resulted in the "soft head hitting the hard brick wall" situation. Why the money changers were so intelligent to divorce the English system in establishing our decimal dollar system in colonial days, but our "scientists" and "engineers" were not, I shall never understand.

While studying for my engineering degree, I estimate that I spent at least ten per cent of my problem-working time making conversions from one system to another and/or the converting from one unit to another in a non-decimal system (i.e., feet to inches, etc.). Probably more time than this was spent. (Perhaps someone could make a study.)

Having performed navigational duties while in the Navy, I disagree with one of your correspondents who suggests scrapping the nautical mile. The conversion from minutes of arc to nautical miles is of great general convenience to those who navigate, even if the direct conversion is not too precise. Retaining this unit with the metric system is not inconsistent.

Also, I would suggest retaining the statute mile for land measurement purposes since townships, etc., are so closely associated with this unit, and because of the real estate and legal problems involved. However, I think that subdivisions of the mile should be decimal rather than yards or feet.

Foremost, I would suggest, as you and others have . . . that the complete manufacturing industry should be converted as soon as it is absolutely possible. To perpetuate an archaic system is to retard learning, research, and product development which, in the long run, cuts down a production edge that we may now enjoy over European and other countries using a more rational system.

While I realize that momentous numbers of dollars might be involved in the conversion of measuring devices to a different system, I have no doubt that, ultimately, it will repay its costs many times over. I am not suggesting that existing expensive calibration machinery be scrapped over night, but, as the military leaders say, "a phasing out" of the old with the metric would be the sensible approach.

The engineers of the past are the ones, I feel, who should take the responsibility for this confusion. It is not my purpose here to place blame, but rather to point out that the engineer, more than any other professional, has the supreme responsibility in using dimensions in fabrication of products and/or building of structures, and therefore, if the engineering profession as a whole could be awakened to the evident facts of dimensional life, then the issue could be more easily resolved.

As steps in a positive program for each engineer and/or other persons who may be directly concerned, I would suggest the following:

- Take a look at your own company's policy as to dimensional confusions, or lack of, and discover locations where the metric system could be used more easily than that presently used.
- Prepare a summary of these findings and submit these to your professional societies and SPACE/AERONAUTICS magazine for dissemination to other engineers.
- Likewise try to determine a realistic "cost of conversion" figure for each device needing to be converted. Is it really as expensive as some people believe?
- Write your views on these matters to your Congressman. Perhaps one of them could reach a man who is farsighted enough to assist this movement at the legislative level.
- Put a penny in a jar every time you have to make a conversion which would not have been required under an all metric system. Use this money to buy yourself a metric scale and—*use it.*

Chiksan Co.
Brea, Calif.

Victor M. Warren
Senior Design Engineer

"Great Savings in Time and Labor"

Your editorial—about the metric system—one of the more important editorials of the year.

Fortunately, I was blessed with teachers who lived by the metric system in both high school and college and it has been a constant source of amazement to me why such a country as ours has not changed to the metric system.

I believe that the English system can give the necessary precision but it must be used with the greatest of accuracy due to its awkwardness and to the possibility of the introduction of additional errors during manipulation of the English system units.

The advantages are many; some of which are scales readily available with decimal divisions, the quick change between large and small units by merely moving a decimal point, and last but certainly not least, the great savings in time and labor. Many errors introduced in the solving and manipulation of problems are never discovered and remain with the system to the end. This can result in costs of staggering proportions.

I fully believe that the present offers a most opportune time to change to the metric system. Further editorial on the subject would be most appreciated.

Flight Test Division
Naval Air Test Center
Patuxent River, Md.

Ephraim J. Stockwell
Head, Data Systems Section
Instrumentation Branch

"Decision-Making" Level

Re your remarks on page 17 ("Engineers for Metric System," Feb. '59): Aren't you overlooking the best spot to get the metric ball rolling, namely your own responsible trade publication and others like it?

If you will look on pages 29-34 of that issue you will find at least five dozen opportunities to test your idea at the "decision-making" level.

3527 Cody Road
Sherman Oaks, Calif.

J. R. Bruman

- We have a better plan. See the May issue.—ED.

Wants to Hear From Production Men

Metrology is the science of pure measurement. In practice it is often restricted to mean measurement of the three fundamental quantities—mass, length and time. All other

more on next page

high-energy fuel briefs from Callery

More HiCal® in the offing for authorized users—A planned boost in HiCal production over the next few months will provide more than enough fuel for immediate military test program requirements. As a result, Callery will have HiCal-3 available for *authorized* users. If you wish to test HiCal-3 in engines or components in your fuel program, write for specific information. New HiCal-3 Handling Bulletin is available on request.

Diborane now available in developmental quantities at reduced prices—Formerly available in research quantities at $400/lb., Callery's new price schedule for Diborane ranges from $35 per lot for 100 grams ($160/lb.) to $80/lb. in 4/lb. lots.

Ten years of R & D on fuels and propellants—Callery's Research and Development Laboratories in Callery, Pennsylvania, are currently rounding out ten years of extensive work on fuels and propellants. Active in this field since 1948, our R & D Laboratories have been carrying out programs totaling $6 million per year for the last five years.

We can now handle a limited number of new projects for other organizations. Areas of primary interest: fuels and propellants, component testing, inorganic and organometallic chemistry.

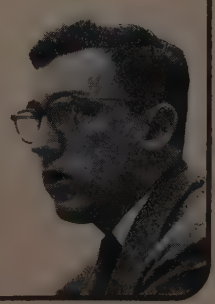
New 15-minute Triethylborane-Tributylborane fire-fighting film available for loan. Just write 9600 Perry Highway, Pittsburgh 37.

Lower cost lithium borohydride available—Callery now offers Lithium Borohydride at prices ranging from $1.00/gr. to $180/lb. in 10/lb. lots. $LiBH_4$ is a solid. It melts at about 532°F with decomposition. Decomposition at 1800°F would absorb more than 6000 BTU/lb. It is soluble in hydrazine with a reduction in freezing point, which improves its properties as a rocket fuel.

Offices now in Washington, D.C., and Dayton, Ohio—To contact Callery in the Washington, D.C. area, phone Richard A. Carpenter, Manager, ADams 4-4200. This new Callery office is in Room 709, DuPont Circle Building, 1346 Connecticut Avenue, N.W.

Our new office in Dayton, Ohio, offers specialized assistance to interested parties in that area. Call Anthony C. Hummel at AXminster 3-2752. Office address is 2600 Far Hills Avenue.

Stuart G. McGriff
Product Manager
Fuels and Propellants
Callery Chemical Company



CALLERY CHEMICAL COMPANY
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Write in No. 167 on Reader Service Card at start of Product Preview Section

quantities such as volume, density, velocity, acceleration, and force are derived from these three quantities.

Metrology is two-folded. First it provides and maintains the standards of reference by which the quantities are compared and measured; secondly it provides the means by which the comparison may be made with accuracy sufficient for the particular purpose. Therefore the systems of measurement are created by the specialist—the metrologist. It is up to them to resolve the problem of "too many inches."

As to the type of system—English or Metric—this will have to be determined by industry and government.

Technologically we are quoted as being approximately three years behind Soviet Russia. Would a change such as this increase or decrease this time span? In comparing the USSR to the United States, Harvard University's Professor Livingstone has stated that the Russians have cut lead time of production of manned aircraft to one-half of our time.

Our current system of measurement is deeply imbedded into our industry. How many drawings are still active in industry that are three years old, five years old or older? To convert these drawings to the metric system would be beyond consideration for much of industry.

How many industrial machines would have to be converted? The cost of this would be tremendous. To date the comments relative to the published editorial have been made by engineers, scientists or people working in the engineering profession. I would like to hear what the production people have to say.

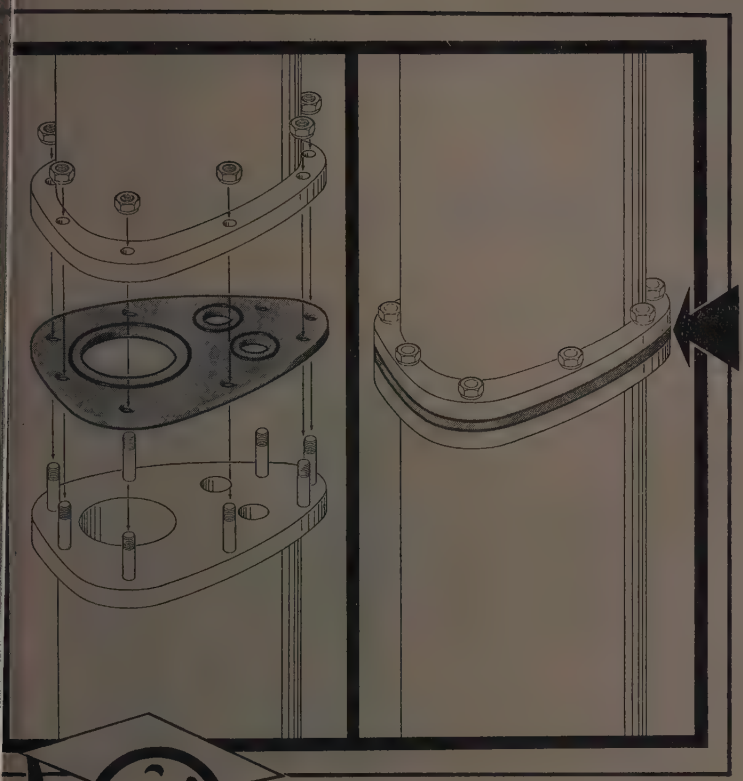
Going back to Prof. Livingstone's statement, it requires the U.S. a period of 2¾ years for the production of a manned aircraft. The USSR has cut this time to one year. If we change to the metric system can we reduce our time span [of] 2¾ years to one year?

Is precision the reason for the change? Precision can be obtained in the English system by the use of decimals. There are available on the commercial market precision measuring instruments which can measure to an accuracy to 0.000001.

As an engineer, I also favor the metric system, but is it an economical, wise move to make at this time? Would a changeover to the metric system set us back a greater span of time than the 2¾ years to one year time span mentioned above?

I would like to see comments from tool engineers and production people.

L. G. Harrison, Supervisor
Standards Publications Dept.
Link Aviation, Inc.
Binghamton, N. Y.



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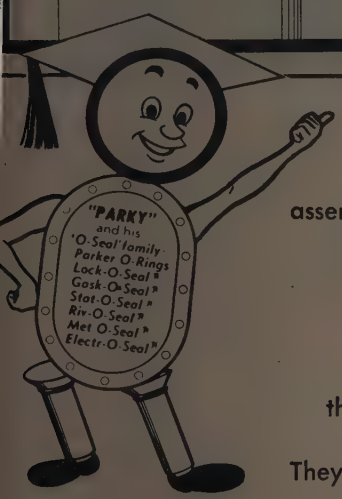

Hundreds of accidents have been caused by seals being left out during assembly or repair, and thousands of production hours have also been lost for the same reason. Just one of the plus values of Gask-O-Seals is that they are practically impossible to leave out because they are inspectable visually after assembly. This can mean many valuable warranty dollars saved, many hours of downtime saved — and it may mean the saving of human lives.

They also provide no-leakage positive sealing, prevent blow-outs. Damaging coldflow is eliminated, high manufacturing and maintenance machining costs are avoided and they are reuseable. If you use static seals in your designs, why not find out about Gask-O-Seals — made by the makers of Parker O-rings.

Parker SEAL COMPANY

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A DIVISION OF PARKER-HANNIFIN CORPORATION

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Purpose—new dimension in engineering

ENGINEERING, in the early days, was "know how", not scientific, and its purposes were quite contemporary. Today, engineering has become scientific, but its purposes must be extended.

Problems and purposes affecting modern engineering spread wide across the world. Engineering itself lies in a broad spectrum of thought. At one end it merges with science. It extends through the detailed technical phases and on to the administrative, where we find it impinging on many areas of government.

Near the scientific end of this spectrum we see new developments in materials, in power, and in thought. There should come the ability to design almost at will — even though with great effort — new materials hitherto never seen on earth. Soon new sources of power will become available for any location.

We see now new aids to thinking and control, applicable not only to physical problems, but serving also as increasingly powerful aids to decision-making in business and government.

Over the past 100 years, engineering colleges have taught a good deal about engineering economy—the arts of design and compromise to meet economic requirements. Today, engineering has further goals to meet: weight, size, and various kinds of reliability.

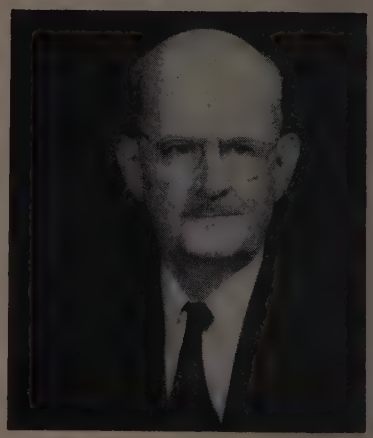
Beyond these are others which must remain undefined by physical measure. Among these are industrial peace and justice, the conservation of natural resources, and problems of true social gain. All these should present challenges to engineering education.

Seemingly terrifying problems bubble up from the desires of many peoples. Various ill-conceived combinations of science, engineering, business, and government have served as catalysts in bringing emotions near the boiling point. If we continue, soon each country (or ruler) may possess the power to destroy another.

What then can we say of engineering education at home and overseas? In both areas engineering needs call for a more scientific base, and for this the new undergraduate curriculums seem well-planned.

Consider the more highly selected men. Experience leading to more technical and scientific work is needed for many who will work in this country; abroad, young men may come sooner to consultative and operating engineering posts.

As in the past, many from both groups will go into administration. Graduate training for all these highly selected men now must be provided. This calls for a changing outlook. Instead of applied scientists alone, advance study must also produce highly trained practitioners, somewhat as it does today in the various fields of medicine.



DR. J. F. CALVERT, Head, Electrical Engineering Dept., University of Pittsburgh

Now, the hardest job in engineering teaching seems to be that of training the scientist-engineer. This is because we still must train a man in research by doing actual research, and not with synthetic stuff. To give such training, we need very able and experienced teachers.

Need to pass their methods on

We are much too ready to draw the potential teachers into engineering practice, where they may work wonders but do too little to pass their methods on. This tendency is being partly corrected in some areas of the country by using the talents of certain men of industry for day- as well as night-time teaching. But this alone will not solve the problem.

More of the scholarly students need further encouragement to stay in teaching and research. There are many long range engineering problems of particular interest to specific industries. Many of these could be supported through consulting arrangements with specific engineering teachers. These are the men qualified to produce in their own right as engineers and qualified to develop the other young men in areas of special competence.

This doesn't present an expensive procedure—only one that commonly is ignored. The primary problem

remains. It is to spend a little more of our highest skill on developing new young talent.

In the past, many engineers for the less developed areas of the world have been Europeans and European-trained. Apparently the training has been sound, more often applied than ours is at present, and usually with less emphasis on the humanities.

I am inclined to guess that—on an immense scale—Russia is to replace Europe in exporting engineers whose technical training will be admirably suited to the needs of less developed lands. I simply cannot believe that from Russia's tremendous outpouring of engineering graduates, anything else may be expected overseas. These men, of course, will render service. Also, they will serve as business emissaries and as missionaries to spread their doctrine.

Except for brief stays and sheltered living, we seem to have few engineers for export. We need sharp changes if we are to increase our own training of students who could come to us from abroad. We need actual recruitment as well as better methods for evaluating the applicant's chances of scholastic success. (Scholastic failure for these men can be catastrophic.)

We need ways to provide for the financial support of these students, because we cannot use foreign nationals on classified research. Neither can we assume them qualified to teach before we've seen them.

We need to develop engineering educational programs geared to their needs and not to assume without plans, as we commonly do for our own men, that American industry will provide somehow for a large proportion of these young men's practical experiences.

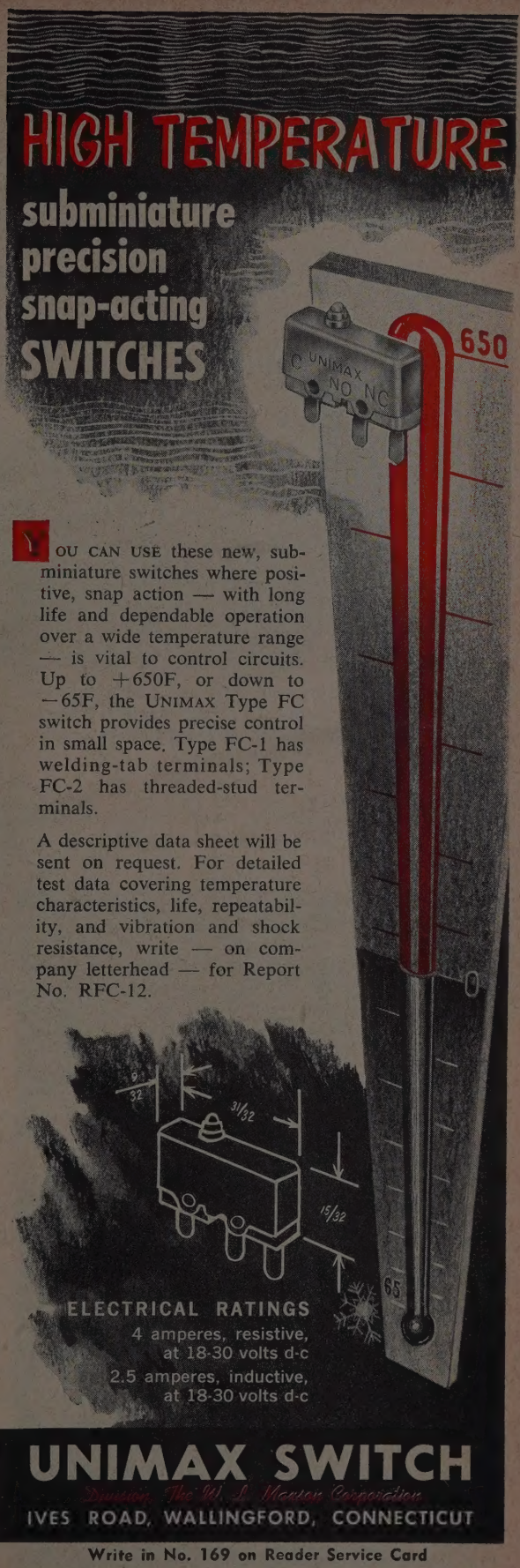
For all young engineers of either domestic or foreign origin, it may be that we should expect more enlivening experiences from our courses in the humanities. This I am hardly qualified to judge, but in increasing numbers the strongest young men will go on to graduate study. Eventually, maybe soon, it will be seen that all advanced study in engineering need not be pointed at scientific and technical research alone—some work should be aimed toward administrative training regardless of one's major field of study.

And why must we allow general studies in the humanities and social sciences to end with the baccalaureate degree? Shouldn't these go on for all graduate engineering programs?

For our own young men and for many abroad, we must seek to extend that part of progress which lies in the direction of purpose, for in this direction lies faith in the future

To explain this in a class room is like trying to pin down with your finger a drop of mercury on the table top. Yet each man from his own viewpoint may still believe in its shining existence and realize that it mirrors light from a source beyond the room. In a direction such as this lies purpose, and here also may be the beginning of understanding.—End

Contributions to this department may be on any subject, technical or nontechnical, about which readers would like to air their views. Names and professional affiliations will be withheld on request.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YOU CAN USE these new, subminiature switches where positive, snap action — with long life and dependable operation over a wide temperature range — is vital to control circuits. Up to +650F, or down to −65F, the UNIMAX Type FC switch provides precise control in small space. Type FC-1 has welding-tab terminals; Type FC-2 has threaded-stud terminals.
A descriptive data sheet will be sent on request. For detailed test data covering temperature characteristics, life, repeatability, and vibration and shock resistance, write — on company letterhead — for Report No. RFC-12.
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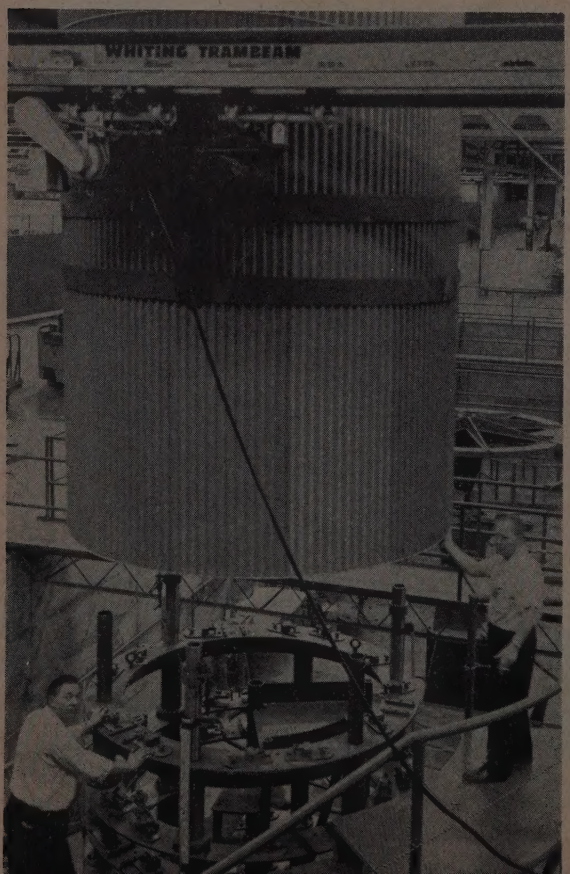
industry briefs

PUSH for new 35,000-ft test track at Holloman AFB, N.M., will be provided by Astrodyne 100,000-lb thrust Mega-boom solid rocket burning for 10 seconds. Sled accelerates to top speed of over 1200 mph.

"WEATHER-EYE" photocells, each weighing 3½ oz, are monitoring earth's cloud cover from Vanguard II. They use f/0.7 optical system, infrared detector, solar battery, and three-inch-diameter mirror.

TAIL SECTION of Army's Jupiter IRBM is transferred from assembly fixture in deep pit to final assembly line at Chrysler Missile Div. plant.



NEW B-2 VERSION of Handley Page Victor bomber is powered by four Roll-Royce Conways of 17,250 lb thrust each. Note retractable scoops on aft fuselage providing ram air for turbo alternators.

MACH 10-27 test capabilities will be provided by new 40-in. electric arc discharge wind tunnel at Boeing. Eight-inch pilot model is shown here. Boeing says this tunnel will be the largest privately owned hypersonic type in the U.S.

Original R. T. Handville painting shows Sparrow III being delivered by McDonnell F4H-1.

SPARROW III AND CECO . . . On the Navy's team of advanced air defense weapons, the radar-homing, air-to-air missile Sparrow III promises to play a starring role.

As prime contractor, Raytheon Manufacturing Company called on Chandler-Evans to produce an important *servo control valve assembly* for use in the missile's radar antenna actuation system.

The ability to manufacture, assemble and test close-tolerance mechanisms — often working directly from the customer's engineering drawings — has earned high regard for CECO as a subcontractor. When demands for quality and accuracy border on the "impossible" . . . ask CECO to review your drawings with the view of producing the necessary equipment on a subcontract basis.

CHANDLER-EVANS CORPORATION WEST HARTFORD 1, CONNECTICUT

Interesting, informative literature on many CECO products is yours for the asking. Please address your request to Dept. 29.

CECO
SYSTEMS
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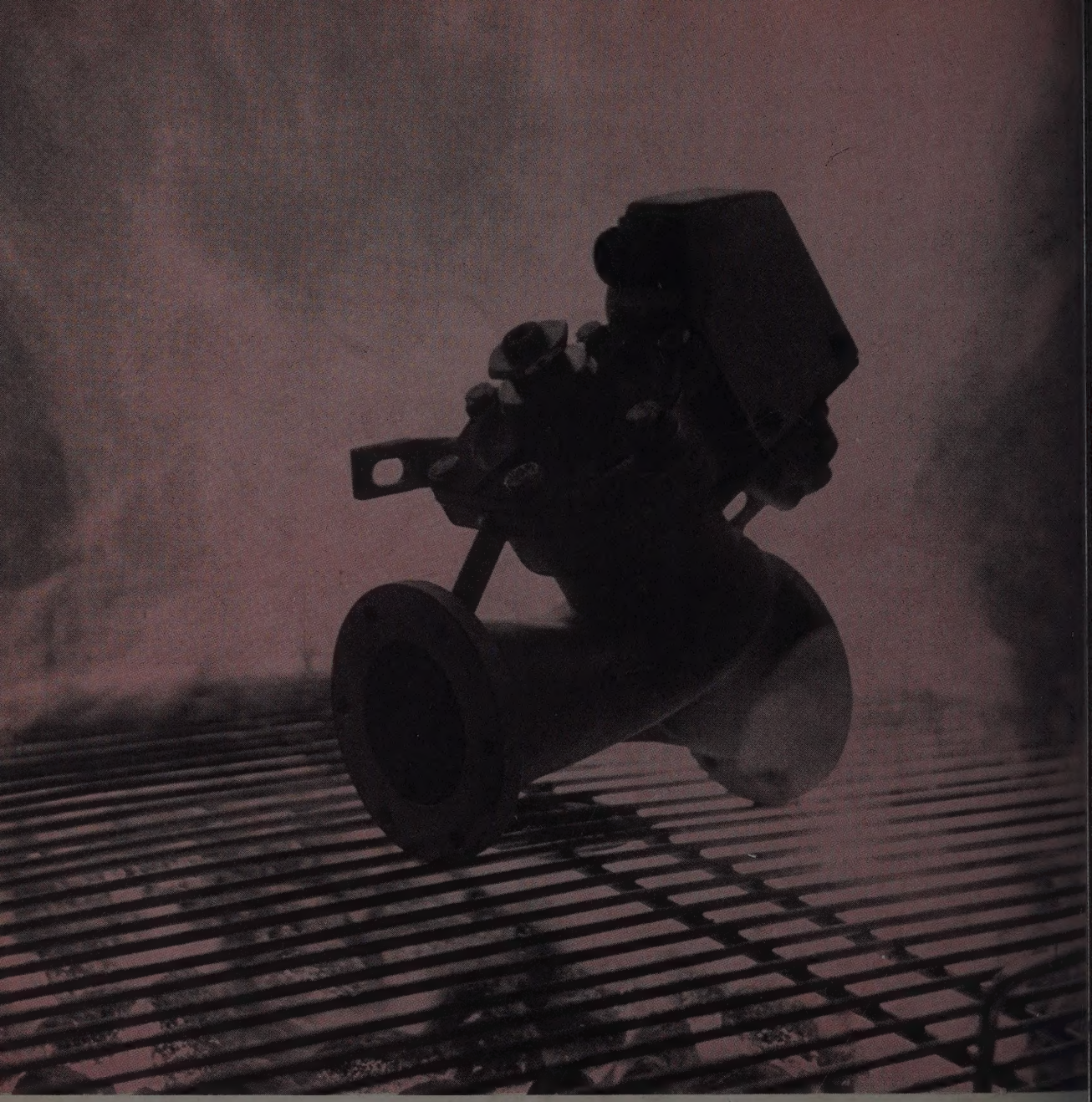

Pneumatic controls . . . well done

Operating temperatures up to 1100°F, ambient temperatures over 500°F. . . These are some of the hot specifications met by Hydro-Aire pneumatic controls currently in production, and we're cooking up higher ratings all the time.

Present applications include controls for anti-icing systems, heating and air-conditioning systems, and after-burner control systems. Our vast range of experience includes piston plug valves, butterfly valves, sliding gate valves, pressure regulators. Units can be supplied with solenoid, motor or pneumatic actuation, as required.

The ingredients: capable, experienced engineers, complete and up-to-date pneumatic test and development facilities, skilled production capabilities. Just mix and mature with fifteen years of know-how . . . Come and get it!

HYDRO-AIRE

BURBANK, CALIFORNIA

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Producing Controls for Every Basic Airborne System

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